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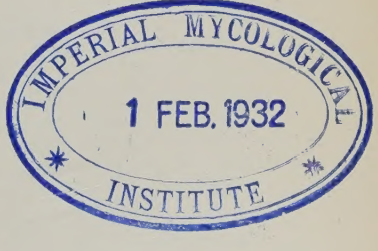

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BROWN BAST.

SOME CONSIDERATIONS AS TO ITS NATURE.

BY

EDGAR RHODES.

The origin and nature of this disease are obscure. Many different explanations have been advanced and the literature is at first sight confusing. Later investigators agree that the origin of the disease is physiological, but an explanation covering all the histological phenomena and the generally accepted evidence as to incidence under various conditions seems to be lacking. The present contribution provides some considerations which add weight to the view that the disease is physiological and intimately linked with the phenomenon of "wound healing" in woody stems. Wound healing on all kinds of trees, temperate and tropical, has been investigated by numerous workers and the factors which govern the deposition of "wound gum" at an open wood wound seem to be universal. The reasons for associating Brown Bast with this general tree reaction will be presented and it will be shown that, considered in this light, a very complete explanation of the disease is possible.

WOUND HEALING IN WOODY STEMS.

A recent paper by Swarbrick (6) provides information of exceptional interest in relation to Brown Bast and his findings are set out.

Swarbrick (6), dealing with the histology of wound healing, examined the effect of making pruning wounds on the branches of temperate zone trees. He finds that, some time after making such a wound, there appears behind the injured surface a block which separates the injured cells from the living ones beneath. The amount and rapidity of appearance of the blocking substance is always greatest during those months of the year when there is active growth and sap movement in the tree, particularly rapid blocking taking place just after wintering. If wounds are made at such a time, starch rapidly disappears from cells below the wound and, coincident with starch disappearance, there appears amongst other substances, a yellow viscous body which actually forms the substance of the block. This body is of an extremely chemically-resistant nature. It is resistant to fat solvents, cellulose solvents and acids except hot concentrated nitric acid which rapidly degrades it. Alkalis cause it to darken in colour but do not dissolve it. When first formed, it gives no reactions for tannins but after some time it develops this property, and with it the property of responding to lignin reactions. After some time, it hardens and contracts and assumes a wrinkled form. This substance,

for want of a better name is called "wound gum" and the occurrence of this body has been reported by many other workers notable among whom is Coster (1) whose observations were made on tropical trees. Swarbrick (6) also established the fact that the time when most active blocking takes place is coincident with that of the greatest activity within the tree of the normally occurring enzymes. When enzyme activity is at a minimum, blocking is much less rapid and may be negligible. A wound made at the wrong time of the year may remain unblocked for many weeks until the enzymes are again active. Then starch will rapidly disappear and wound gum be laid down. From the work of Swarbrick it is established that the general conditions for wound gum deposition are:—

(1) Living starch bearing tissue abutting upon dead or dying tissue.
(2) Activity of the enzyme system normal to the tree.

General Histological Characteristics of Brown Bast.

The observations made by Rands (3), pointing as they do to the occurrence in diseased tissue of this wound gum are of great interest. Rands (3) has described the secretion which causes the discolouration typical of brown bast in the rubber tree. He observes that in disease cases, the discolouration begins at a small point or points at the tapping cut and extends downward and laterally into the undamaged cortex towards the base of the tree. The presence of discoloured areas of this kind below the cut form the chief external characteristic of the disease. The secretion itself is a yellow viscous substance which Rands (3) decides is produced by the living cells surrounding certain of the latex vessels, into which it often makes its way. It is a noteworthy fact that the vessels are always the centres round which the secretion of this substance takes place, (See Plates 2 & 3.) Rands (3) has observed that the rate of deposition of the viscous body is variable and is always most profuse in vigorous trees growing rapidly, while in trees spare in growth and lacking in vigour, the amount of material deposited may be negligible. In affected vessels the latex is observed to have coagulated. Areas of cortex, severely discoloured, no longer yield latex. Rands (3) describes the nature of the secretion and finds that, when newly formed, it is plastic in nature but later it hardens and contracts and assumes a reticulated appearance. It is particularly insoluble and resistant. Fat solvents and cellulose solvents are without effect. Acids, except hot concentrated nitric acid which degrades it, are similarly incapable of effecting solution. Alkalis produce a striking darkening in colour but do not dissolve it. When newly formed, it responds to no microchemical reactions for lignin but after some time it develops this property and also gives fairly definite reactions for tannins. Sanderson and Sutcliffe (4)

have also noted independently the occurrence of a body giving tannin reactions. Rands (3) came to the conclusion that the secretion occurring in brown bast tissue was of the same nature as the wound gum described by various investigators as occurring at wood wounds in other trees. He made further observations upon the effect of making a single cut in healthy Hevea cortex, and found that there usually appeared within 24 hours, a yellow body secreted uniformly along the wound by the living parenchyma cells beneath. This secretion was localised to a narrow zone quite close to the injured surface. The application of the various microchemical tests described led him to the opinion that the body occurring in small amounts at any such cut, was of the same nature as the wound gum occurring extensively round the vessels in cases of brown bast. He also observed that at such a single wound the appearance of wound gum was followed in a week's time by suberization and the laying down of a cork cambium behind the injured zone. In a similar manner he noted the appearance of the same substance when wounds were made in the wood of Hevea as distinct from the cortex. These observations led Rands (3) to the final conclusion that brown bast was an accentuated type of wound response. It now seems to the writer very unfortunate that Rands was not able to suggest a mechanism to explain the phenomenon.

Rands (2) in another paper, dealing mainly with tapping experiments, has shown that with estate trees, a greater frequency of tapping is usually productive of more cases of the disease. He also notes cases where, when tapping was very drastic—six times a day—trees ceased to yield, the contents of the vessels were coagulated but there was practically no deposition of the gum, and the discolouration which would bring such trees under the arbitrary heading of "brown bast" trees was therefore absent. He says (3) p 4....."With other conditions viz. during dry weather, on defoliated trees or isolated bark areas, the tapping cut may be wholly dry, yet the secretion of gum may be so slight as not to cause noticeable browning of the cut."

The investigations of Sanderson & Sutcliffe (4) direct special attention to another aspect of the disease. They show that very serious disorganization of the latex vessel system is brought about by the establishment of adventitious meristems in the neighbourhood of the vessels in affected parts of the cortex. The adventitious meristem, arising in the cells between the vessels, introduces new actively growing tissue into a zone in which cells are all mature. The zone enlarges as a result and the vessels which bound it are in consequence displaced and often broken. Sometimes the meristem behaves as a secondary vascular cambium cutting off wood elements to the inside and phloem elements to the outside. When this occurs, a hard woody burr is built up within the cortex. The development of such burrs may make the tree completely useless because the tapping surface becomes so irregular that tapping is impossible. (See

Plate 1 A and Plate 4.) These workers also note, that in bad cases of the disease, starch may very largely disappear from the cortex.

Sharples and Lambourne (5), as a result of extensive tapping experiments, came to the conclusion that the disease is physiological in origin and is caused by loss of vigour of the vessels as a result of tapping. They describe how bursts of disease may occur at irregular intervals during a year and these are in the nature of a "trigger action" phenomenon. They note that, while the high yielding tree usually develops the disease most readily, the moderate and even the poor yielder may on occasion become affected.

Taylor (7) visualizes the initiation of brown bast, as a result of the death of vessels in the functional part of the cortex.

The Relation of Brown Bast to the Universal Wound Healing Phenomenon.

These findings of the later workers on brown bast, appear at first sight to have no definite link between them. It occurred to the writer however, that if the conclusions of Rands (3) could be associated definitely with the more recent work of Swarbrick (6), it might be possible to obtain a clear mental picture of the mechanism of the disease and one which would rationalize and bring together the views of the various investigators.

It became therefore a matter of some importance to verify the histological data of Rands and definitely to decide that brown bast gum is the same as the wound gum of Swarbrick. The writer, after carefully examining the histological characteristics of diseased Brown Bast cortex could only conclude with Rands that, in so far as it is possible by microchemical tests, to establish identities in such ill-defined, non reactive secretions, the brown bast gum, the localised secretion at a cut in healthy cortex and the secretion at a wound, are all of the same nature and consist of wound gum. They are clearly of the same nature as the wound gum described by Swarbrick. It should be stated that wound gum is in no sense a gum, nor is it a resin, than both of which it is far more resistant. Its exact chemical nature is unknown and is likely to remain so, until a solvent is found or until some means is discovered of bringing it into solution without degrading it into substances so simple as to afford no clue to its original constitution. The term wound gum, although a misnomer, will be applied to the substance to indicate its probable identity with the body so described by the other investigators.

The writer in some additional macrochemical investigations upon diseased cortex, compared in a semi-quantitative manner the soluble substances in

(a) Very severely diseased tissue,
(b) Less severely diseased parts of the same tissue,
(c) Normal tissue.

The material was all taken from the same tree at the same time. Ether, alcohol and water solubles were considered and rubber, fats, sugars, glucosides, true tannin, amino-acids and colouring matters were examined. It was found that the only products accumulating in major quantities in diseased cortex were sugars and glucosides. There appeared to be an increase in the amounts of fat, rubber, and true tannin, but the differences obtained were not such as could safely be considered significant. The only major decrease was in the amount of starch. The products which accumulate are those which normally accumulate in the neighbourhood of wounds. Starch too is the substance which Swarbrick has observed to disappear when wound gum deposition is proceeding.

Thus, brown bast tissue contains not only wound gum but also an accumulation of those soluble substances which occur at wounds. A definite connection is thus established between the disease and the phenomenon of wound healing.

The Mechanism of the Disease.

At any tapping cut in a healthy tree, a localised secretion of wound gum is laid down. In a brown bast tree, wound gum is deposited not only along the cut, but also in greater quantity along the length of some of the vessels downward from the cut towards the base of the tree, that is, in situations where mechanical injury cannot have occurred.

Now the general conditions governing wound gum deposition, are known as a result of the work of Swarbrick (6) and since the parenchymatous cell near a vessel does not differ from the parenchymatous cell near an open wound, if the same conditions be realised along the length of a vessel, which are realised close to a healthy cut, then the parenchyma near a vessel must secrete wound gum as if at an open wound.

From a consideration of these general conditions (see page 2) it will be seen that a very simple happening will produce gumming along the length of a vessel. If a functional latex vessel dies back from the cut, downward along its length into the living tissue below, at a time when the enzyme system is active, the parenchyma surrounding the dying vessel will be in a similar state to that just behind the injured cells at a knife cut. They will secrete wound gum around the vessel and along its length, to the point where die-back has ceased and so lay down wound gum in what may be termed a "brown bast location."

Further, if by any means whatever, a die-back once started can automatically extend down the vessel, then gumming will be able to follow (given correct enzyme conditions) and a travel of discolouration along the vessel system such as is usual in brown bast cases will

result. Now a cell wall at death becomes freely permeable to the cell sap of the surrounding tissue and with this in mind, the writer carried out experiments which are of direct interest. Pieces of bark, freshly removed from the tree, were subjected to the vapour of chloroform for half an hour. They were then centrifuged and the sap, so removed, tested for acidity with a capillator apparatus. It was found that this sap was frequently as acid as pH 5.2 and since it is known that rubber latex flocculates at pH 5.0—5.2, the permeability of the vessel wall at a die-back at once assumes importance as providing a means by which a spread of discolouration may take place. The entry of such a cell sap at a small die-back would bring about the coagulation of the latex and probably the cell protoplasm to a point a little further down the vessel, thus extending the dying region. It is difficult to visualize the vessel continuing to pursue its normal functions in that part of its length in which so drastic a phase reversal has taken place and in which its contents have become literally a plug of solid rubber. The extension of the dying zone would allow of the entry of more cell sap, causing the pathological affection to travel still further along the vessel and this process, automatically repeated, could create a steadily lengthening path for wound gum deposition which is attendant upon the pathological or semi-pathological condition of the vessel.

Gumming once started under favourable conditions in this way, will be able to spread along the vessel system both downward and laterally, since the vessels in each ring frequently anastomose.

The somewhat unusual nature of the cortex itself thus provides a means by which a spread of discolouration is possible under favourable conditions.

Conversely and as a test of the correctness of the present view, if a die-back were induced in some vessels of a tree of little or no vigour, or in a vigorous tree temporarily reduced to an inactive condition, (as during defoliation) or in an exhausted area of cortex such as results from heavy experimental tapping of isolated panels, then with enzyme activity reduced to a minimum, the bark should on occasion become dry, with the contents of its vessels coagulated, but discolouration should be absent. There should be coagulation without gumming. The cases recorded by Rands (2) (see page 3) in which this result is shown to have been obtained under just such conditions, lend support to this suggested mechanism.

A discoloured area of cortex having been established as a result of a die-back, then just as a cork cambium is laid down behind the localised secretion at an open wound, meristematic activity may also be initiated around gummed areas within the cortex, in the manner described by Sanderson and Sutcliffe (4). This activity, by causing the breakage and death of vessels perhaps in another row and perhaps previously functional will produce new sites for gumming and, apart altogether from the ultimate burr formation and disorgani-

zation of the cortical tissues, will act as a powerful instrument in the spread of discolouration, not only in vessels of the same row, but as between row and row. The introduction of this latter factor completes the picture of the mechanism involved in a severe case of brown bast.

Viewed therefore as a wound healing phenomenon, the mechanism of the disease is simple. As a result of tapping, a random and occasional die-back or drying-out may take place in a vessel or vessels of the tree. Subsequent events are governed in such a case by the universal conditions for wound gum formation. One of these conditions is activity of the enzyme system normal to the tree. Thus, gumming can be very rapid or very slow. This factor is closely linked with the vigour of the individual tree and is one which previous explanations of the disease have not been able to take into definite account.

It will however be seen that the mechanism agrees with and covers the findings of the various recent investigators. Sharples and Lambourne (5) have come to the conclusion that the disease is initiated by a loss of vigour in the vessels as a result of tapping and the present explanation, in terms of the wound healing phenomenon, demands what is essentially the same thing, namely a random die-back as a result of tapping, producing a pathological condition in the vessels. Taylor (7) also predicts the death of a vessel previous to its becoming a seat of brown bast. The subsequent laying down of wound gum covers all the observations of Rands (2 & 3) and the findings of Sanderson and Sutcliffe (4) form another very essential part of the mechanism. Viewed in this way, recent investigations lose their isolation. They fall nicely together to give a much clearer picture of the disease, and the whole is definitely linked with a universal tree reaction.

Brown Bast as a Manifestation of the Wound Healing Phenomenon.

It is now possible to consider the incidence of Brown Bast under various conditions and such a consideration shows that some rather obscure observations, permit of a ready explanation.

When trees are in tapping, cell contents, proteins, carbohydrates and mineral salts as well as caoutchouc and water are being regularly removed from the vessels. This will either have no effect on the vigour of the vessels, or it will tend to produce a premature pathological condition. One can safely assume that, very occasionally, a vessel or two in a few of the trees will tend to die-back a little way below the injured zone at the cut into the living and undamaged parenchyma. This random and occasional occurrence produces the initial seats for brown bast discolouration near the cut. Now the

regular operation of tapping, also tends to oppose the establishment of discolouration, because the excision of cortex tends to carry away small gummed areas. Tapping thus introduces opposing tendencies. Trees which develop brown bast are those in which the deposition of gum at an embryo seat of disease has been able to outpace removal by the knife. The greater the tendency to rapid gumming the greater the likelihood of the development of disease. It has however emerged that gum deposition is governed by enzyme activity so that the greater the enzyme activity within the tree the greater the predisposition to brown bast.

(a) *The vigorous tree and brown bast.*—The well grown vigorous tree is normally in a state of greater enzyme activity than the ill grown feeble specimen and an average estate population contains trees of all degrees of vigour. We are thus provided with a reason why the well grown tree usually develops brown bast more readily than its more feeble fellows. In the vigorous tree, gumming at an embryo seat will always be more profuse and more liable to outpace removal by the tapping knife.

(b) *Bursts of Disease.*—The activity of the enzyme system of a normal tree varies in the course of a year over a considerable range. It is low when the tree is about to winter and during defoliation. It is high when the tree is re-foliating after wintering and growth is actively proceeding. In the tropics there are subsidiary bursts of growth, which occur at irregular intervals. These are largely governed by climatic conditions and each burst involves a burst of enzyme activity. The reason for the occurrence of sudden disease bursts after wintering and at other irregular intervals is thus immediately apparent.

(c) *Halts in the spread of discolouration.*—It is often noticed that a discoloured area on a tree may cease to enlarge and remain stationary for a long time after which it may quite suddenly begin to enlarge again.

When and if conditions in a tree become adverse to growth and enzyme activity, gum can no longer be laid down. The necessary pathological condition may be present in many vessels, but gum deposition cannot proceed, until improved growth conditions are re-established.

(d) *Frequency of tapping and incidence of disease.*—Under estate conditions, the change to a heavier tapping system, say from alternate daily to daily, is usually productive of a greater brown bast incidence.

It is apparent that the more frequently the tree is tapped and its vessels are denuded of contents the greater will be the chance of a small random die-back occurring in a few vessels of a few trees. Thus the greater the frequency of tapping the greater the chance of producing an embryo seat of disease. But the greater the frequency of tap-

ping, the greater the excision of cortex and the greater the chance of removing such embryo seats of disease. There are two opposing tendencies. Now it has been recorded by Rands (2) and the record is typical, that under good conditions, discolouration has been observed to spread down a panel at the rate of one metre in less than a month. This rate is more than thirty times greater than the rate at which cortex is excised by daily tapping. It follows then that the factor of excess cortex removal will only be of significance when gumming is proceeding at low speeds. When enzymic activity is such that gumming is able to proceed even at one-tenth of this optimum speed, the excess bark removal will be powerless to prevent the establishment of gummed areas of cortex. Thus, when and where enzyme activity is reasonably high, the chief factor in disease incidence will be the greater tendency to produce more embryo seats. Now on the average estate the ill-nourished tree type usually forms only a small proportion of the whole, the majority being reasonably well grown and vigorous. In such an area, over an average year, the tendency to produce more embryo seats will in general be the more important factor. A greater tapping frequency is therefore predicted as likely to produce more cases of brown bast in the average estate population, but exact proportionality between frequency and number of cases can obviously not be expected, nor is it observed.

(e) *Number of cuts per inch and incidence of disease.*—A reduction in the thickness of the shaving removed at each tapping usually results in a greater incidence of brown bast.

The gumming begins from points at the cut. The rate of deposition is variable as between tree and tree and from time to time, dependent upon the vigour of the individual. Thus in trees of lesser vigour and activity, and in times of lesser activity in the more vigorous trees, that is when the thickness of a shaving can exercise any measure of control, the thicker shaving by tending to eliminate more completely any small seats of disease will in general be expected to produce fewer well established cases of disease.

(f) *The anomaly of the small-holding.*—It is a remarkable fact that there are usually far fewer well developed cases of brown bast on the small holding than on the average estate. It is known that tapping is usually very drastic and a great number of cases would at first sight be expected, yet the actual incidence is very low. Estate managers rightly observe that if such drastic tapping systems were applied to estate trees, the percentage of brown bast cases would be enormous. The apparent anomaly of the small holding is usually dismissed by saying that bark consumption is so high that it constantly removes diseased cortex. Now this explanation is not of itself sufficient, for assuming the small holder to indulge in twice daily tapping and to make as few as fifteen cuts per inch, he would then be removing cortex

at the rate of not more than five inches per month on any one panel, which is less than one-seventh the rate at which discolourations have been observed to spread. While this high bark consumption cannot fail to have a great effect in removing diseased cortex, if it were the only factor operating against the disease, there would still be an appreciable brown bast incidence. A correct conception of the disease must provide a ready explanation of this apparently anomalous state of affairs.

Now it is also the fact that the average small holding contains infinitely more permanently "dry trees" than the average estate. Trees of this type, in which practically all the vessels have ceased to be functional and which must be tapped very close to the cambium in order to obtain even a small flow of latex, abound in the small holding. They show no discolouration and do not therefore come under the heading of "brown bast" trees. This fact is rarely mentioned, nor is it usual to consider it as having any relation to the brown bast problem.

The average small holding is closely planted and the individual trees are usually ill-nourished, thin, hard barked specimens in comparison with estate trees of similar age. They are tapped heavily and the result is that vessels die-back exactly as in an estate tree. The pathological condition necessary for wound gum deposition is produced in their vessels as it would be on the estate tree but wound gum deposition cannot in the majority of cases follow. The enzymic machinery is so feeble as to be unable to produce discolouration. Their case is exactly analogous to that described by Rands (see page 4) for estate trees heavily tapped during defoliation, or on isolated bark panels. The cortex is dry, the contents of the vessels are coagulated but there is no discolouration. The small holding presents fewer brown bast cases, because it has so few even reasonably vigorous trees. For the same reason it presents more cases of trees which are "dry" but which might otherwise be "brown bast" trees.

Summary.

Brown bast disease is a phenomenon closely related to the tree reaction of "wound healing" and obeying the same general laws.

When the disease is considered in this light, the chief findings of the various recent investigators are brought together into a harmonious whole.

A pathological condition, occasionally induced in a few vessels by the operation of tapping, is followed by the deposition of wound gum and the formation of burrs.

The deposition of wound gum is essentially an enzymatic process carried out by enzymes normal to the tree and the disease being thus enzymatic in its operation, is closely linked with the state of vigour of the individual concerned.

The linking of the disease with enzyme activity and tree vigour enables a simple explanation to be made of many obscure but fundamental points connected with its incidence.

A new light is thrown upon the relation between "brown bast trees" and "dry trees" in small holdings.

Acknowledgement.

The writer desires to thank Messrs. Sanderson and Sutcliffe for their interest and assistance, while the investigation was being carried out in the Pathological laboratory of the Institute.

Thanks are also due to Mr. Sutcliffe for his help in producing the various photographs and to the Rubber Growers' Association for permission to reproduce the photographs comprising Plate 1.

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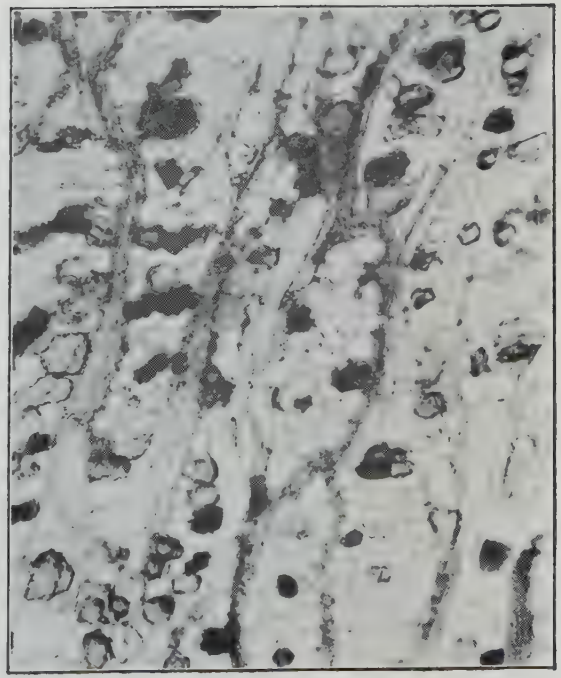
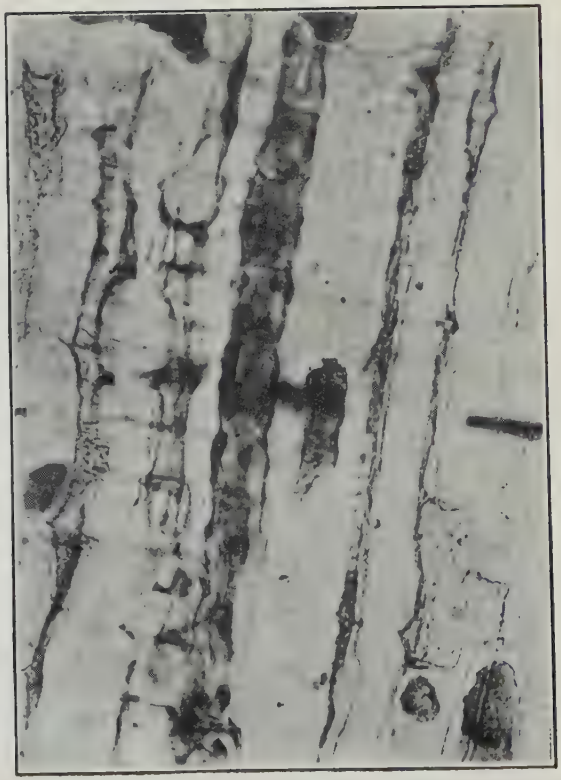
A. Heavy Burring in a fifteen year old tree.

B. Longitudinal cracks in the bark of an eleven year old tree.



A. Tangential Section showing "gumming" of vessels. × 150.



B. Radial section showing light "gumming" in neighbourhood of a vessel.

A. Transverse section of severely diseased tissue showing very heavy "gumming." × 150.

B. Radial section of severely diseased tissue showing large "gum" masses. × 150.

Radial section through a young burr.
Vessels displaced. × 19.

INTERNAL FISSURES IN HEVEA CORTEX.

BY

H. SUTCLIFFE.

Some time ago a visit was made to an estate, at the request of the manager, in connection with a disease causing a number of lines or stripes which appeared on the tapping surfaces of a number (130) of old trees that were growing on different parts of the estate. The trees were about 21 years old.

At first sight the panels appeared to be affected by a very unusual form of "Black Stripe Canker" but the stripes were not spreading irregularly and no fusion of the stripes was taking place. The tapping system was a single cut on a quarter of the tree on virgin bark and the cut was about 40 inches from ground level.

In most cases the lines ran from the top of the panel to the tapping cut, about 10 inches, but in some instances the lines began half way down the panel and ran to the cut. The number of lines varied from one to eight and were not quite parallel to each other but were slightly wider apart at the lower ends and all the lines were inclined at a slight angle, 6.8° to 8.7°, to the right from the vertical, following approximately the course of the latex vessels. The distance between the lines varied considerably as shown in Figs. I and II.

The lines appear as a callus about 5.mm. wide on the renewing bark and resembled old wounds, such as might have been caused by a knife being drawn down the tapping panel, a corky powder being formed, the edges of the lines growing towards each other and forming a slight bulge in the process of healing due to the formation of cork as shown in transverse section in Fig. III. On cutting into one of the lines with a penknife a dark brown stain appeared which extended through the cortex beneath the line down to the wood. The tapping cut, after removal of the scrap, showed a whitish spot where the line passed beyond the cut into the untapped cortex below. On the untapped bark the cortex when cut into showed the same brownish stain which also extended down to the wood. As far as could be seen no open wounds were being formed nor did the disease appear to be doing any serious damage to the tapping panel. The lines did not show on the untapped bark either above or below the tapping panel, which seemed to be normal in every way. Below the panel, behind the untapped bark, the lines finished at a previous renewal below the present tapping cut while above the tapping the lines extended into the untapped cortex two or three feet above the panel.

A section of the tree including the whole panel and a foot above and below the panel, was subjected to further examination.

The cut ends of the section showed the lines quite distinctly as whitish places in the untapped cortex. On removing pieces of the untapped bark and wood with a chisel it was found that the lines were present in the cortex and wood as pear shaped masses of tissue, with the narrow ends pointing towards the centre of the tree, and they had quite a distinct structure from the surrounding cortex and wood (Fig. IV.) In the process of tapping, the lines showed very plainly on the renewing cortex as the overlying portions of bark and cortex were removed.

No fungus or other organism was found which could be the cause of these peculiar lines.

Internal structure.

Thin transverse sections were cut through the lines in the untapped cortex, and when examined microscopically showed a very different structure from normal wood and cortex. In the untapped cortex the lines appeared as definite cavities or fissures filled in some cases with loosely arranged parenchymatous cells with numbers of stone cells scattered amongst the loose cells. On staining the sections with a solution of Sudan III it was seen that, in addition to parenchymatous cells and stone cells, coagulated latex also occurred. In addition a large number of cells containing a tannin like substance were also found. The regularity of the rows of latex vessels and bast tissue is interrupted by these abnormal fissures which stand out quite distinctly, surrounded as they are by normal cortex (Fig. VI.)

The transition between a fissure in the cortex and a fissure in the wood is shown in Fig. VII, where it will be noticed that the cambium is in a very active state of division.

The total transverse length of a fissure is 12.7 mm. of which 4.9 mm. is in the cortex and 7.8.mm. in the wood while the greatest width of the fissure is 2 mm. measured near the cambium. That these fissures are deeply seated in the cortex is shown by the fact that in the case illustrated the total thickness of untapped bark and cortex is 15 mm. while the distance from the cortical end of the fissure to the outside of the bark is 10 mm. and from the sclerenchyma ring the distance to the end of the fissure is 6.7.mm.

In the wood the 'V' shaped fissure is filled up with regularly shaped thin-walled cells characteristic of cambial activity which, instead of becoming lignified and forming wood cells as they would in the ordinary course of events, remain unlignified. This is shown in Figs. VII, VIII, IX, where the normal wood tissue with large vessels is seen on either side of this V shaped fissure. It will be seen that the point of the V begins between the ends of two medullary rays.

It is difficult to account for the origin of these fissures in the wood and cortex but it would seem that at some time previously,

possibly a year or more, the cambium near the ends of one or two medullary rays, for some reason, ceased to form normal wood cells and normal cortex cells at this point and remained in a juvenile condition while the cambium cells on each side of this juvenile tissue produced wood and cortex in the normal fashion. This active cell division caused the displacement of some of the rows of latex vessels near, in addition this displacement caused the latex vessels to burst with the result that the latex flowed between the cells in the fissure. Such a condition may often occur in untapped trees or even in tapped trees above the tapping area without any outward sign of any fissures.

Bobilioff (1) describes similar fissures which he found on the tapping surfaces of a number of trees on an estate in West-Java. In one case he found as many as 113 fissures on one tree alone. Eight is the largest number which have been reported in Malaya.

From his description Bobilioff does not appear to have found any cases where the fissures occur in the wood as well as in the cortex. One of his figures (Fig. II) shows the fissures in close connection with the cambium but there is no indication in the figure that the wood is in any way affected by the abnormal growth.

On another estate in Malaya nine trees were seen which showed these lines on the tapping panels. These trees were about 12 years old. Fig. I. is a photograph of one of these showing only two of the lines. The origin of the fissures was investigated in this particular tree and found to be quite different from the previously described case. Fig. X is a photograph of a transverse section of the cortex and illustrates the cortex just before the fissure makes its appearance. It will be seen that the cortex is more or less normal in every way. Fig. XI shows the first appearance of a group of stone cells and a slight bending or displacement of the third, fourth, fifth and sixth rows of latex vessels from the cambium which is the free edge of the section. Figs. XIII, XIV, XV and XVI illustrate the various stages of the formation of the fissure. Fig. XVI shows the final stage where the fissure is filled with coagulated latex.

The total bark thickness is 7.7.mm. and the fissure is 6.1.mm. from the outside bark; the fissure is 1.1.m.m. long transversely, 5.mm. wide and 1.3.mm. from the cambium.

It will be seen from the illustrations (Figs. X to XV) that this latter case differs considerably from the former (Figs. VI to IX) in that in the formation of this fissure no wood is involved and it is more or less comparable to the cases which Bobilioff describes in which no fissures are formed in the wood. He shows, (Fig. II) that the fissures arise from the cambium and are originally continuous with it but later on the fissures become widely separated from the cambium owing to the formation of new cortical tissue so that the fissures are apparently pushed further out into the cortex.

In the case under consideration (Figs. X to XVI) it will be noticed that the fissure never had at any time any connection with the cambium but arose suddenly in the soft bast. The fissure was traced from a well defined place in the cortex to a place where it was not visible in the cortex and thin transverse sections were made of the cortex towards the well defined area until the beginning of the fissure made its appearance.

The cause of the formation of the fissures is unknown but Bobilioff suggests that it is due to a differential growth rate between the hard and soft bast which causes splits or fissures to appear in the soft tissue which later become filled with cells and coagulated latex. This however does not seem to apply in cases where the wood is affected.

SUMMARY.

A description is given of the formation of internal fissures in Hevea cortex which have not previously been reported as occurring in Malaya although they have been found in some trees in West-Java. The cause of the formation of the fissures is unknown but it has been suggested that the formation is due to a different growth rate between the hard and soft bast.

I have to thank Dr. Rhodes of the Institute for help with the photomicrographs and also Mr. Gunnery for taking the Photograph Fig. I.

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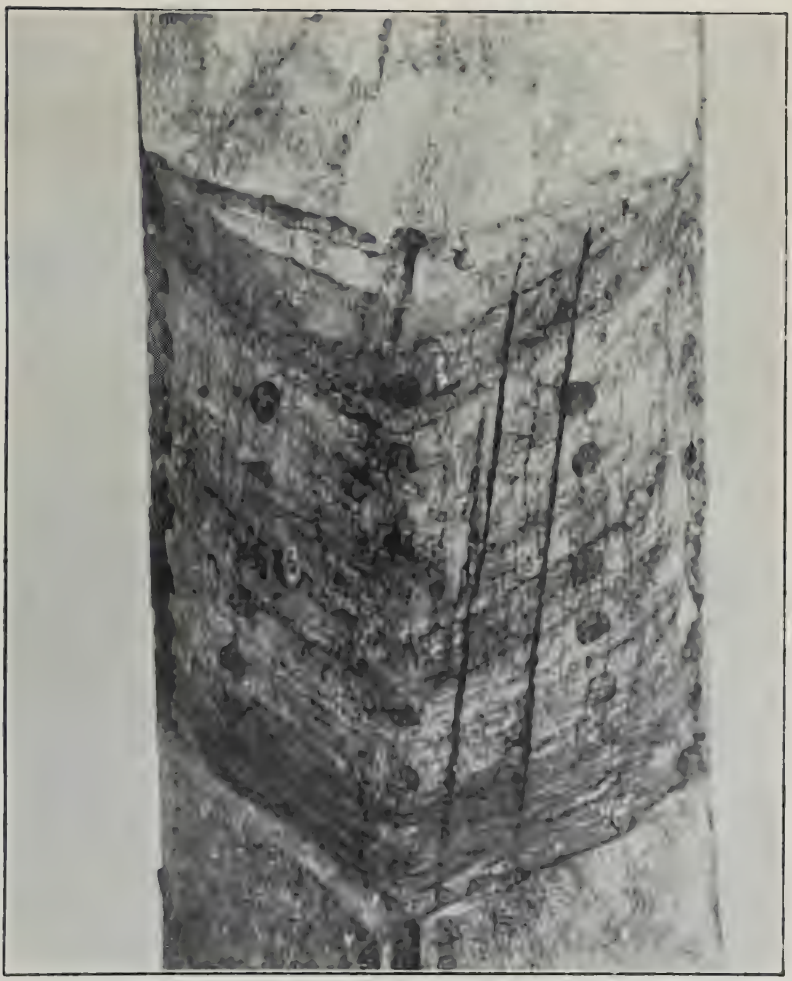

Fig. 1. Photograph of a tapping panel showing two lines or fissures on the tapped area.

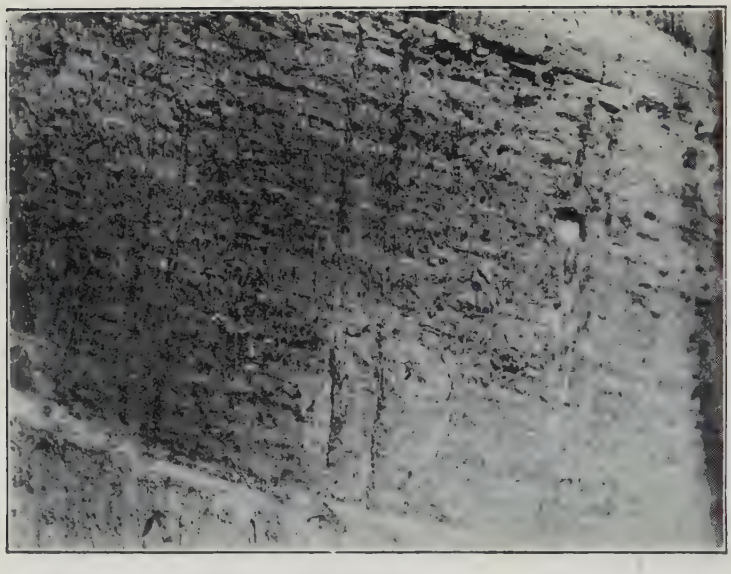

Fig. II. Photograph of a tapping panel showing six lines or fissures on the tapped area.

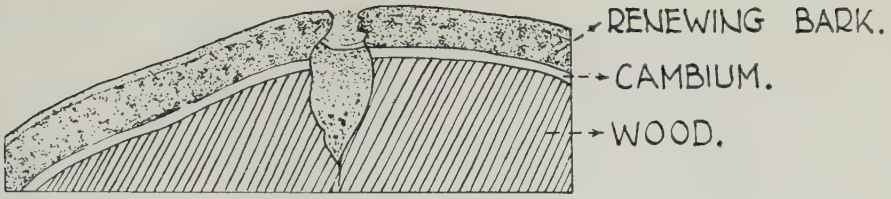

Fig. III.

Transverse section through the renewing bark showing the healing of the fissure.

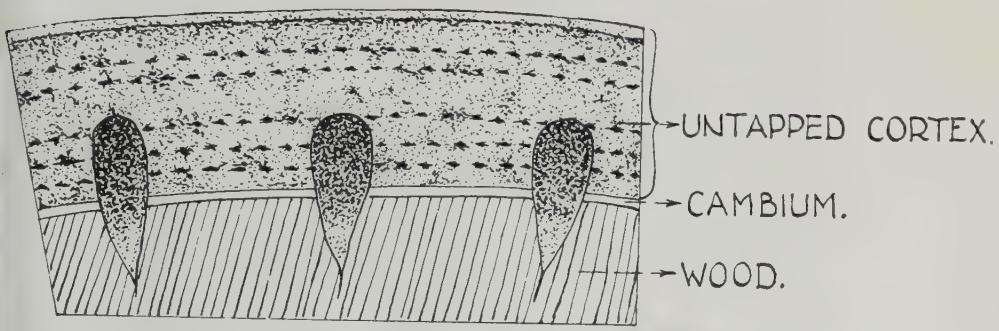

Fig IV.

Transverse section of untapped cortex showing fissures in the wood and cortex.

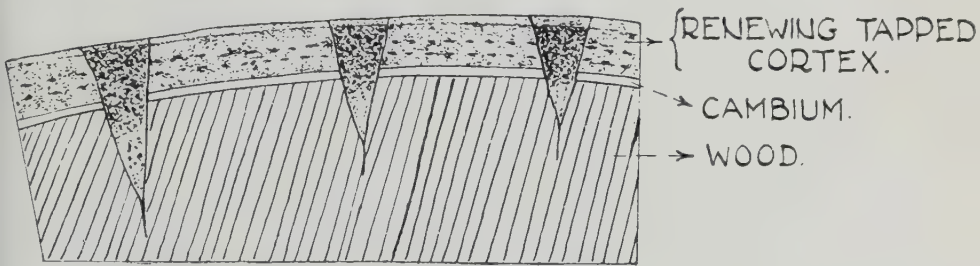

Fig V.

Transverse section of tapped cortex showing the ends of the fissures after removal of the outer cortex during tapping.

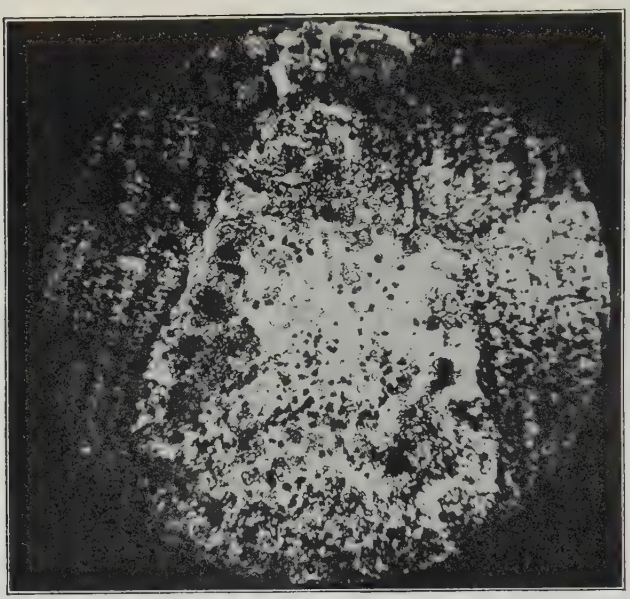

Fig VI. Transverse section through a fissure in the cortex. × 20.

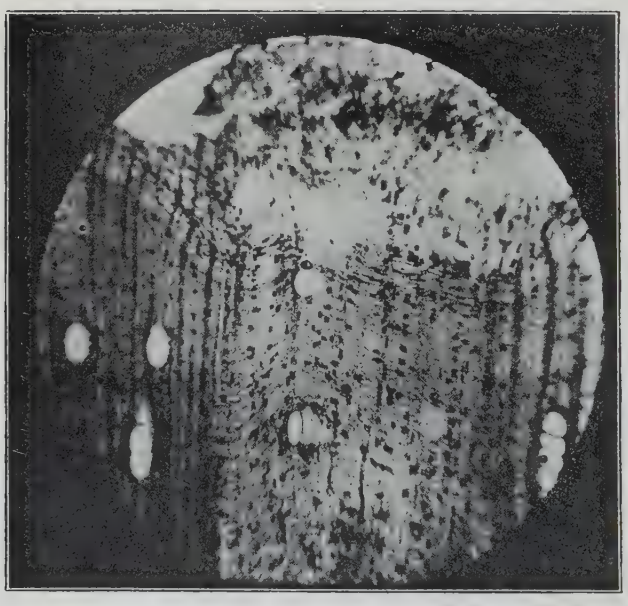

Fig. VII. Transverse section showing the actively dividing cambium between the fissure in the wood and the fissure in the cortex. × 20.

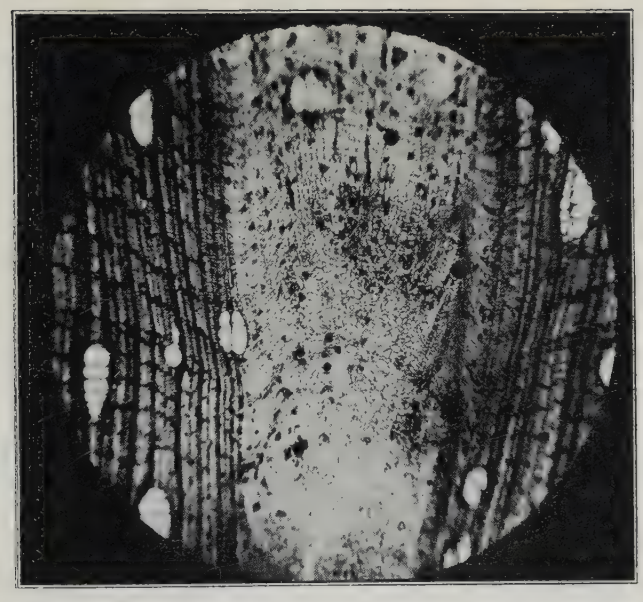

Fig. VIII. Transverse section showing structural difference of the fissure compared with that of the wood on each side of the fissure. × 20.

Fig. IX. Transverse section of the fissure showing the origin from cells near the medullary rays. × 20.

Fig. XIV. Transverse section through the cortex showing the fissure filled with coagulated latex. × 20.

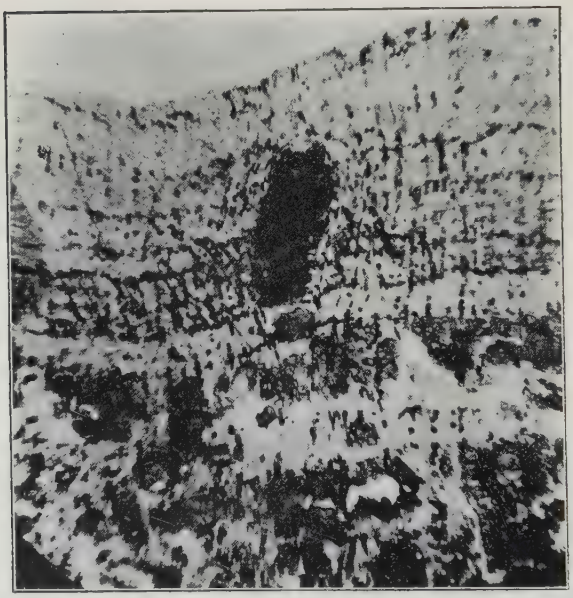

Fig. XV. Transverse section through the cortex showing the fissure at a later stage with a larger quantity of coagulated latex. × 20.

SOME OBSERVATIONS ON THE MILDEW LEAF DISEASE OF HEVEA BRASILIENSIS DUE TO OIDIUM HEVEA.

BY

A. R. SANDERSON.

With two exceptions viz. *Fusicladium macrosporium,* and Abnormal Leaf-fall due to *Phytophthora* sp. mature rubber trees have until comparatively recently been singularly free from any serious leaf disease and more especially does this apply to the Eastern tropics.

The former (*Fusicladium macrosporium*)—a most destructive enemy of the rubber tree—is fortunately still confined to the Amazon Valleys, Trinidad, British Guiana and Surinam, while the latter—Abnormal Leaf-fall due to Phytophthora—has so far not proved serious in Malaya if it has appeared at all. This leaf disease is however a source of considerable trouble in South India and also perhaps to a lesser extent in Ceylon and Burmah.

The appearance of the Oidium Mildew dates from 1918 and was first noted by Arens (1) in the Malang district of West Java. As the following quotation will show, Arens realised the possible capabilities of this fungus and warned the industry to keep a sharp look out for it. In his account the following occurs: "It is not confined "to the Malang country, but is present over the whole of Java. The "disease is apparently a new one. Nowhere in the literature on "diseases of Hevea has Mildew been recorded as growing on Hevea, "neither from Java, from Sumatra, the Federated Malay States, "Ceylon or other rubber growing countries. But since the disease "is easily overlooked if not attacking many trees, it seems not "impossible that it may already be present in other rubber growing "countries."

The truth of the last suggestion has been fully borne out during the last ten years for now the Oidium leaf disease has been reported from Sumatra, Ceylon and Malaya.

In Java and also in Ceylon it has already assumed the character of a serious leaf disease requiring active combative measures on a large scale and at considerable cost. Its steady spread and increase in intensity must be regarded seriously, even though it has not yet caused any considerable damage in some of the rubber growing areas. The fact should not be lost sight of that once it appears in a rubber growing area, it is very liable to recur under suitable conditions, and that each recurrence usually means a more virulent attack as well as an increase in area affected. The appearance of the Oidium Mildew on Hevea in Ceylon was first noted in 1925, and since then

the area and intensity of attack have both steadily increased. The disease was first noted in Malaya in 1925, and has appeared again in 1929, but the fact that so far no great damage has resulted in Malaya, should not lull one into a feeling of false security. The out-break of this disease on an extensive scale is always a by no means remote possibility. The fact that the fungus is in the country and can carry on from one season to the next favourable time is to say the least, disconcerting.

Reydon, (8) in a report deal'ng with the Mildew Disease in East Java, 1927, states as follows:—

(1) " The Mildew disease has become considerably worse during the last few years, as compared to previous years."

(2) " Mildew has appeared on nearly all East Java estates."

(3) " The attacks of the disease have been severe on 48 per cent. of the total Mildew infected estates."

(4) " Mildew has appeared on the budding beds or nurseries of 17 per cent. of the estates."

(5) " Decrease of production was accounted to Mildew attacks on 6.4 per cent. of the Mildew estates."

(9) " The rainfall on Mildew estates during the East Monsoon was less than on healthy estates."

(10) "Mildew is considerably worse on low-lying than on high-lying estates, and again more severe on the south than on the eastern slopes of the fields."

Schweizer (11) writing of the Erysiphaceae from Java, mentions that the largest number of the said Mildew (Erysiphaceae) host plants are especially virulently attacked in the dry season (the wintering season of the rubber tree) and further states that on some plants the Oidium is found through the whole year. He considers that the variation of the water supply is more especially to be considered and that the better the water supply the less the various plants suffer from Mildew attack. This explanation is in agreement with the experimental results obtained by Rivera (9). It is highly probable that many factors are concerned in causing infection and also in determining its intensity and spread, but although the great variability of these combinations is generally admitted, two conditions must be satisfied viz. the young leaf formation and weather conditions favourable for attack. It is clear then that the time of wintering is all important.

Variability of combination of factors for successful inoculation by another species of Oidium is well shown by the investigations of Miss Schwarz (10) who found the same species of Oidium in West Java on *Physalis minima* and on tobacco, but infection experiments

in East Java with Physalis which is infected the whole year through with the Mildew gave no results with tobacco. The explanation is probably that the necessary combination of factors is not present.

Gadd (5) writing of the conditions obtaining in Ceylon when the first outbreak was noticed in 1925, states:—" Normally at the time " when Hevea is putting forth its new leaf, weather conditions in " Ceylon are dry and not favourable for fungus growth. In 1925 " there was more rain and the number of wet days was greater than " usual during February and March in the rubber districts, and it " is probable that these wetter conditions favoured the fungus and " helped the process of adaptation to its new host. If so, given " normal climatic conditions at the time new leaves are next produced " it is unlikely that the trees will be severely attacked as what infec- " tious material has persisted on the old leaves will be shed with " them in wintering."

Sharples (12) comments on this as follows:—

" This year—1926—wintering was even and normal. Up to date " (4/4/26) not a single case of leaf-fall has been reported this year. " Thus Gadd's conclusion can be emphasised. ("Consequently " given dry climatic conditions at the times of production of new " leaves, it is not expected that the disease will recur to any extent ")."

Murray (7) writing on the occurrence and significance of Oidium leaf disease in Ceylon remarks on the differing characteristics of the disease in the different districts. A dry district like Matale and a wet one like Kalutara are contrasted. Of the former district (Matale) the abundant superficial growth of mycelium and spores on the surface is a notable feature, whereas in the latter (Kalutara) district it is comparatively rare to find an affected leaf on which the fungus is visible to the naked eye. In the Matale district the leaves are sometimes so white as to appear to have been splashed with white wash. He suggests that this difference is probably related to different atmospheric conditions and more especially the difference in average humidity which is lower in Matale than in Kalutara.

Occurrence.

In general once the Oidium leaf disease has appeared, the spread has been certain and fairly rapid throughout the area where the host plant has been well distributed. The severity of attack has not necessarily been coincident with or proportional to rate of spread, because this depends so much on conditions which may not be continuous throughout any particular district. There is at present however a general concensus of opinion amongst the various investigators, that dry conditions even to drought are favourable to a maximum intensity of attack, if such conditions obtain during or immediately after the wintering season i.e. before the new leaves have reached maturity. Murray states (7) that Oidium is not so severe in the low

country as in certain districts at higher elevations, while Reydon (8) writing of conditions in East Java states that Mildew is worse on low-lying than on high-lying estates. It would appear then that the necessary favourable conditions may occur at different altitudes in the different rubber growing countries.

In connection with this Rivera (9) states:—" Everything which " tends to decrease the turgency of a leaf e.g. drought, sudden " differences of temperature etc. makes the leaf more sensitive to " Mildew attack."

A diminished cell vitality also increases its susceptibility to attack by the Mildew fungus.

Effect of Mildew attack on Yield of Hevea.

At present no reliable figures appear to be available as to the effect of Mildew attack on yield of Hevea, but there can be little doubt that repeated defoliations must be harmful. The effect on yield of Abnormal leaf-fall due to Phytophthora has already been noted, and that due to Mildew disease can scarcely be expected to be less harmful. Ashplant quotes yield figures in the case of Phytophthora Leaf-fall for Southern India, showing that the sprayed blocks in some cases yielded 18 lbs. per acre more than unsprayed blocks and in other cases 9 to 18 lbs. more per acre. A second effect on the tree is a general reduction in vitality following the depletion of food reserves. This may in some cases occur to such a degree that comparatively weak parasites can gain entry which would be impossible with a tree in full vigour. Stoughton Harris (14) writing on the spraying of rubber as a means of control for abnormal leaf-fall mentions that there is definite evidence that the sprayed trees have a greater girth increment, hold their leaf longer at the normal wintering period, and give a yield estimated conservatively at 10 lbs. per acre greater each year than unsprayed rubber, and further remarks, " the control of a leaf disease should be looked on not from the point " of view of possible immediate yield response but as a prevention " of the future general debilitation caused by the disease."

Murray (7) writing of the attacks in Ceylon, states, that " in " consequence of a continual depletion a physiological die-back of " twigs is a characteristic feature of badly attacked areas."

So far as the writer knows this has not been noticed in Malaya perhaps because the attacks up to the present have not been sufficiently severe.

Recurrence.

The Hevea Mildew is known only in the Oidium stage i.e. the conidial stage. In this it agrees with most tropical Mildews the ascospore stage of which is not known. Spread must therefore be by

the conidia or by the mycelium or by movement of infected material. This cannot always account for recurrence in the same areas year after year, and since no ascus stage is known, there is no spore stage known capable of carrying over from one wintering period to another. The inactive period in the life history of the fungus has been discussed by Bally and by Bobilioff (4). The latter states that the fungus hibernates on the few young shoots which are always produced by some trees throughout the year, or on infected spots of mature leaves. In an affected field there are always at any given time a few trees whose young shoots are infected and these are the sources of infection when the conditions are suitable for an outbreak of the disease.

Murray (7) commenting on this states, " In the main, observations " on the life history of the fungus in Ceylon confirm Bobilioff's state- " ment, except that in badly affected areas in certain districts the " fungus never becomes wholly inactive, so that the disease is present " at all times of the year." This agrees with Schweizer's account of the Erysiphaceae of Java.

It would be of considerable interest to have particulars of the distribution and amount of rainfall in these districts.

Although the various investigators are more or less in accord that diseases due to powdery mildew (Oidium) attain their maximum severity under dry weather conditions, and that attacks in general, whether severe or mild, are coincident with dry weather even to drought conditions, this is probably not the whole truth.

Reydon (8) states that " to conclude herefrom that more rain "means less mildew is in our opinion rash, because we do not know " exactly the nature of the influence of the rains on mildew attacks, " and we must first find out when the young leaf period falls. The "mildew attack is indeed in the first place dependent on this last " factor." With the last sentence all investigators will agree but it would seem that periods of heavy rain may do much to check the spread by spores (conidia) since these would be washed off, and fall to the ground; the fungus being an obligate parasite, and the conidia not capable of retaining vitality long under adverse conditions i.e. unless on a suitable living host, thus germinating power is soon lost.

It would appear however that, in conformity with Reydon's statement, any tree producing new foliage, when the spores are active, will be liable to infection. The period of activity of the spores may to a considerable extent be limited by the weather conditions, since spore production is usually much more rapid and continuous during dry weather.

Another factor of importance is that this condition according to Rivera (9) is an optimum one for infection so that the condition favouring spore formation is also the condition favourable for attack. The rapid spread noted on many occasions may thus be accounted for.

Mites & Mildew.

Whilst it is true that mites have been found on some occasions in association with the Oidium it by no means follows that the attack by the fungus must be preceded by mite attack. The Oidium fungus is an obligate parasite and requires only the presence of the host plant and the necesssary favourable conditions as regards the cell turgidity to make a successful attack. One reason for finding the two together is the fact that both show their greatest development under the same climatic conditions. It is fortunate perhaps that the most effective treatment for mildew is also the chief means of combating mite attack.

The Causal Fungus.

Oidium Hevea belongs to the "Powdery Mildews" (Erysiphaceae) many of which cause destructive diseases of plants. The delicate, hyaline, cobweb-like mycelium usually develops on the surface of leaves forming a more or less complete superficial covering. In the case of *Oidium Hevea* in Malaya a complete covering is not common. This agrees with Murray's observations in the Kalutara district of Ceylon. From this mycelium special haustoria or sucking organs are formed which penetrate the cell walls and draw their food supplies from the cell contents. Although these fungi are mainly leaf parasites they may occur on flowers, fruits and stems.

Spores (conidia) are usually produced in abundance on short, erect conidiophores, and are chiefly responsible for the powdery appearance which is characteristic. The spores are distributed by wind, insects or other agency, but are usually short lived, so that if conditions are unfavourable the spread of the disease is soon checked. By destruction of the cell tissues of the leaves this type of fungus may prepare the way for the entry of other and weaker parasites which may quickly complete the destruction started by the Oidium. It is probably because of this that such fungi as Gloeosporium and Fusarium are so frequently found associated with Oidium attack.

Symptoms.

The attack of mildew in mature rubber is always most pronounced on young leaves, during and immediately after the wintering season. The young leaves in the bronze, greeny bronze, and later, pale green stage, are particularly liable to attack. It may, however, attack leaves of all ages.

In the case of young foliage the leaves usually become more or less dull in appearance, as contrasted with the shining appearance of healthy leaves, crinkled from the tip and later a portion commencing at the tip becomes bluish or purplish black in colour. These changes

apply to the leaves both in the bronze stage and early green stage. The leaflets soon fall to the ground and become shrivelled in appearance. The mycelium and spores can be seen best near the midrib on the under sides of the leaves. In cases of severe attack the ground may be covered with a carpet of decaying leaves and the retention of the more or less bare leaf stalks on the trees almost denuded of leaflets is a striking characteristic. The next flush of leaves may be attacked in the same way and fall to the ground long before they are mature. It seems fairly obvious that several repetitions of such a leaf-fall during any one season may have serious consequences. Recurrence in successive years must have a cumulative effect. The attack on mature leaves is usually not nearly so severe as on the younger leaves, and frequently the mature leaves remain attached to the leaf stalks. The attack on the flowers if at all severe is followed naturally by a poor seed season. This has been very marked in some cases both in Malaya and in Java.

Control Measures.

Control measures fall naturally under three heads.

(a) Measures applied to the plant direct to enable it better to withstand, to recover from, or to ward off attack, e.g. application of manures, general improvement of soil conditions.
(b) Breeding of more or less immune strains.
(c) Direct attack on the parasitic fungus.

(a) These measures should be used, if used at all, in conjunction with (c). Any attempt, e.g. manuring etc. alone, to keep the plant vigorous which still leaves the fungus free play can scarcely be considered the most efficient. Further, unless some form of manuring could be applied which would render the plant completely resistant either by increasing the thickness of the cuticle—the outer covering of the leaf—or affecting the constitution of the cell would be of doubtful efficacy. The fact that in any case the young leaves are the most susceptible complicates matters considerably. The combination of manuring and spraying i.e. (a) and (c) has had good effects in the case of abnormal leaf-fall due to Phytophthora.

Vollema (19) describes manuring experiments as a possible means of combating mildew attack of Hevea.

Three aspects are considered.

1. "Influence of manuring on the power of resistance of the young leaf to mildew.
2. "Influence of manuring and other cultivation measures on the time and existence (duration ?) of wintering.

3. "Influence of manuring and other cultivation measures on the recuperative powers of affected trees.

"As regards (1) the conclusion arrived at was that the manures in use applied shortly before wintering cannot in any important degree increase the powers of resistance of the young leaf against mildew."

(2) The conclusion arrived at is:—

"Appropriate manuring and other cultural measures by "their delaying influence on wintering make the chance "of attack by mildew greater."

And as regards (3) "last year's deductions were confirmed that "recuperation of manured trees is better."

Vollema finally states, "making up the profit and loss account, "we must conclude that little is to be expected of an indirect attack "on mildew by manuring. As apart from conclusions with the effective "and cheap sulphur dusting, manuring as a rule merely keeps the "attacks in hand by postponing wintering. Although recovery is "certainly better, prevention is better than cure" counts in this case "to the utmost."

(b) Breeding of immune or highly resistant strains offers obvious advantages but at present must go hand in hand with control measures as (c). Little is known at present regarding immunity of Hevea to disease either generally or specifically, and the raising of immune strains would be a long and tedious process. In any case it would not help present plantations. Direct attack on the fungus must at any rate for the present be regarded as the best line of control and sulphur or sulphur compounds are at once indicated.

The use of sulphur in the control of Oidium of the vine dates back to 1846 and it is estimated that at present, France alone consumes 80,000 to 100,000 tons of sulphur per annum for the work. The fungus is still present and active but the damage is negligible.

Use of Sulphur.

It may be said that the value of sulphur in spraying mixtures or dusting powders is proportional to the percentage of "free" sulphur and to the fineness of the particles. The adherence of the sulphur depends largely upon the size of the particle; sulphur with particles 5 μ to 15 μ can now be obtained. A considerable amount of experimental work with the use of sulphur and sulphur mixtures and compounds against the Oidium fungus has already been carried out chiefly in Java, in those districts where the disease has appeared annually with increasing virulence.

Gandrup and S' Jacob (6) describe the results of experiments in the control of Mildew using Bordeaux mixture, Burgundy mixture,

Sulfinette—a lime sulphur preparation—and sulphur. They demonstrated experimentally the effectiveness of Sulfinette and of sulphur in a vaporous form i.e. without the fungicide actually coming into contact with either the fungus or the infected material.

They also discovered that the resin-soda adhesive medium often causes fungicides of standard strength to burn the young leaves and suggest that Sulfinette must be used at 0.25 per cent mixture to prevent burning. The final conclusion of these investigators is that the expenditure necessitated for control work would only be justified by the loss of production being proportionately large, or if capital loss caused by depreciation of the estate through Mildew permits such expense.

Bobilioff (4) carried out observations on Oidium attack during 1929, and concludes as follows:—

"Sulphur and sulphur preparations have a fungicidal effect on "Oidium. When experimenting with different preparations it is not "possible to differentiate conclusively between the effectiveness of these "preparations. However when dusting gardens it appears that the sul- "phur from the sulphur works Kawah Poetih gives promising results " n comparison with other preparations. On the fungicidal action of "sulphur several experiments were carried out, with the following "results."

(a) "The sulphur is effective ten days after dusting.

(b) "Sulphur destroys Oidium when applied to the leaf even "when there is no immediate contact with the leaf spot. "Dusting one side of the leaf is sufficient to destroy the "fungus situated on the other side."

(c) "An influence of sulphur at a distance was not observed, "but this point still wants confirmation."

(d) "A prolonged residual effect of sulphur does not exist. "When dusted trees after a certain time produce new "leaves, these are attacked by Oidium."

(e) "The effectiveness of sulphur on Oidium spots is not ab- "solute. From the boundary of the destroyed fungus spots "the fungus may develop again. On once treated leaf "new Oidium spots may occur. The effect of sulphur is "however not imperfect to such an extent that this is of "practical influence on the Oidium control by dusting with "sulphur."

" 5. When combating Oidium in rubber gardens we made the "following observations.

(a) "The Oidium attack is checked by sulphur. The treated "gardens have practically speaking a normal appearance "and have nice foliage."

(b) "An extraordinary blossoming was observed in the treated "gardens more than 90 per cent of the trees were in "bloom."

(c) "Oidium first decreased between ten applications of sul- "phur (after 10 days) to increase again later on (after "17 days)."

(d) "The influence of rain on the effectiveness of sulphur is "of little importance and Oidium decreased in the ordinary "manner."

(e) "The chance of infection of treated gardens by neighbour- "ing non treated plots is relatively small. Thus it is "possible to dust badly attacked parts without it being "necessary to dust the whole plantation or division."

CONTROL.

For control purposes some form of spraying or dusting is a necessity. The material to be used is as previously indicated sulphur or sulphur compounds or preparations which will act like sulphur and become effective in a vaporous form. There are advocates of both spraying and of dusting and each method may have its advantages or disadvantages.

Spraying.

For this purpose the choice has to be made of a hand spraying outfit or of some form of power sprayer. In either case to be really effective the apparatus must be capable of delivering a spray to a height of 50—70 feet i.e. if the tops of mature trees are to be reached without climbing.

Ashplant (2) discussing the spraying of rubber in connection with the Phytophthora Leaf-fall in South India and comparing power and hand sprayers states as follows:—

"The maximum height that can be reached with a fine spray "operated from the ground is from 30 to 40 feet and is not much "greater with a power than with a hand sprayer. With both, climb- "ing has to be resorted to in order to reach the tops of the trees. It "is this necessity for climbing that limits the possible task and takes "so much time and labour. Could means be devised whereby the tops "of 70 to 100 feet Hevea trees could be reached by a ground operated " spray, or rather by a battery of sprays the full resources of power "driven sprays would be capable of utilization. The greater speed and "labour saving then made possible would alter the position entirely to "the advantage of power sprayers."

If some form of petrol motor is employed one at least of the attendants would need to possess the necessary skill and training to manage the apparatus.

Sundquist (15) discusses the use and advantages of stationary plants with spray guns for the spraying of orchards. Amongst the advantages are saving of time and labour, more efficient work and avoidance of damage to trees by hauling. This system—a permanent one—is now established in the apple growing districts of the Pacific North West.

Tengwall (17) describes experiments with sulphur dusting from aeroplanes and states as follows:—

"Technically the dusting was a complete success; on each leaf "sulphur could be recognised even on the trees at the utmost limit of "the estate. On the old leaves sulphur occurred principally on the "top side; on the young leaves, still hanging, sulphur was observed "on both sides."

"An evident smell of sulphur remained in the gardens many days "after dusting was finished."

"On September 12th it was observed that all the young leaves "which had grown out during or after the first dusting (in August) "were perfectly healthy. Even young leaves, on the trees which "had been badly infected and lost most of their foliage, were healthy."

As a result of the 1928 experiments Tengwall observes that the following conclusions can be drawn:—

1. "Dusting sulphur powder from an aeroplane on Hevea planta- "tions is possible."
2. "Sulphur powder is able to kill Oidium or at least its "conidia."
3. "A dose of 50 kg of sulphur per hectare—45 lbs per acre— "is sufficient to keep the young leaves healthy for at least "14 days."
   "The dusting experiments were repeated in 1929 on a larger "scale in order to get figures concerning the cost of dusting "by means of aeroplanes. This was found to be ap- "proximately 6 florins per hectare equivalent to about 1.7 "dollars per acre, an amount which could probably be "appreciably reduced."

Altogether the operation of power spraying on a large scale, under present conditions must of necessity be expensive and the pros and cons for its installation require careful consideration. The urgent necessity, should it arise, would however, be the deciding factor.

The following account of spraying apparatus and equipment is taken from the R.G.A. Bulletin Vol. 8 No. 7. 1926, and is a report by R. H. Stoughton-Harris, Mycologist, Rubber Research Scheme Ceylon (14).

"In Ceylon and S. India the apparatus is used for control of "abnormal Leaf-fall due to Phytophthtora. There are at present in "use in South India several makes of spraying machines, but of

"these two have proved most successful and one in particular. Atten-
"tion will be confined to this one only as it is understood that some
"50 or more of these outfits have already been sent to estates in
"Ceylon. The machine referred to is the D.S.P. "Headland" Pump.

"This is a double-barrelled force pump, with a large inlet hose
"with strainer, a steel pressure-chamber, and two ½ in. outlets with
"stop-cocks. The machine is sent out unmounted, but should be fixed
"to a small wooden platform, with four projecting handles for carry-
"ing. Spares for the pump are supplied but may usefully be
"augmented. A list of the more useful spares may be obtained from
"the Research Scheme. Two lengths of hose are required, each 75-120
"feet long If more than this length is used, undue wear and many
"bursts and other troubles are probable. The only hose that has so
"far proved capable of standing up to the rough usage is the
"Armada" Hose. To the end of each length of hose is attached
"either a bamboo "lance" (a long bamboo, with a screwed metal pipe
"within it), or a light 15 feet steel pipe. To the end of this is
"attached the nozzle. Many types of nozzle have been tried, but
"the most successful are the Mistifier Junior," and the "Jumbo"
"nozzle. A new type of combined lance and adjustable nozzle has
"been put on the market at the instigation of Mr. Ashplant. This
"is called the Drake & Fletcher "Armada" Spray Gun, and seems
"likely to prove very successful. With this instrument the type of
"spray produced is varied by turning the stop-cock at the handle
"end."

"Besides the actual spraying apparatus there will be required
"for each machine:—

Four 40-50 gallon wooden barrels.
Two half barrels.
Two wooden buckets.
Two galvanised iron buckets.
Two fine mesh latex strainers.
Two old coagulating dishes.
Six empty kerosene tins for water carrying.
One spring balance, weighing to about 30 lbs. or
One household scales.

LABOUR.

"The number of coolies required for each machine will vary ac-
"cording to the distance of the point of operation from a water
"supply. The labour is best apportioned as follows:—

"Two coolies working the pump.

"One coolie stirring Bordeaux Mixture and relieving pumpers
"in rotation."

"Four coolies spraying, two on each line.

"Two to six coolies carrying water, and mixing the Bordeaux."

DUSTING.

The operation of dusting i.e. the use of a fungicide or insecticide in the form of a very finely divided dry powder possesses certain advantages as compared with spraying, and more especially in the case of tall trees like mature rubber trees.

The operation is in no way dependent on the proximity of a water supply. The material used is easily transported. A fine dry dust may remain suspended in the air for an appreciable time and this is an important factor in distribution.

With certain materials the operators have to exercise the greatest care if eye, nose and lung troubles are to be avoided, but precautions involving the use of masks etc., can be taken.

In the case of mixed plantation e.g. rubber and tea, the deposition of sulphur on the tea leaves might reasonably be objected to as possibly leaving an objectionable taint. Recent experiments described in the Mycologist's Report for January 1930. Rubber Research Scheme Ceylon, suggest that even the maximum amount of sulphur per acre which may be expected to fall on tea adjacent to dusted rubber will not taint the tea.

A further experiment showed that although there was a recognisable smell of sulphur on the green leaf and during manufacture the finished tea showed no taint.

Dusting with sulphur by use of a power duster requires considerable care. With some types of apparatus there is always the possibility of the finely divided sulphur becoming ignited and the danger with a petrol engine is obvious. It was at first considered essential that in order to be effective the leaves should be more or less covered with the spray fluid or dusting powder, and that the fungicide must remain attached for a considerable time. Recent work would appear to show that this is not so necessary since in the case of both Sulfinette and of sulphur the vapours have proved successful. A new form of power duster named the Bjorklund Duster has recently been tested against the Oidium leaf disease in Java.

The apparatus consists of a special type of 6 H.P. motor combined with a specially designed "dusting" apparatus to form a single unit. The complete duster weighs about 180 lbs. ready for use and can be carried by four coolies. An automatic feeding device allows the quantity of sulphur used to be regulated. A capacity of about 260 acres per day is claimed for this apparatus.

For application to nursery plants or young plants in the field which do not exceed say 8 to 10 ft. in height some form of hand sprayer or duster would probably fulfil all requirements. It would appear that the time is approaching when each large estate or group of estates will have to consider the question of installing an efficient

spraying and dusting equipment with the necessary chemicals as part of the ordinary estate requirement so as to be prepared for emergencies. In doing this the rubber industry would only be following the example of other large crop industries.

SUMMARY.

1. It has now been definitely established that Oidium leaf disease is present throughout the rubber growing areas of the Eastern tropics excepting S. India and Burmah.
2. There is a general tendency, in all the areas affected, for the disease to increase in intensity in successive years.
3. The fungus can continue in an inactive state from one favourable season to another.
4. The repeated defoliations in a single season which is a marked characteristic of Oidium attack must have an appreciable adverse effect on latex yield, as well as affecting the general vigour of the tree.
5. Original infection and rapid spread of the disease is favoured by dry weather conditions during the wintering season.
6. Control can be established by the use of sulphur or sulphur compounds sprayed or dusted over affected areas.
7. Repeated sprayings or dusting are necessary at somewhat short intervals during the wintering season.
8. The use of power sprayers or dusters or possibly the use of aeroplanes is indicated for the more or less immediate future.
9. The Oidium has been found to be capable of attacking rubber of all ages from nursery plants upwards.
10. The spread of the fungus is by spores (conidia) probably wind borne.
11. The conidia are produced most abundantly during dry weather i.e. under weather conditions such as are experienced during a normal wintering season, and when the leaves are presumably most susceptible to attack.

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BLOCK 6 MANURING EXPERIMENT, R.R.I. EXPERIMENT STATION.

SECOND REPORT.

BY

W. B. HAINES.

The preliminary report on the Block 6 manuring experiment which appeared in the last issue of the Quarterly Journal can now be augmented by a more detailed consideration of a new series of measurements.

Heights were recorded on December 17th 1929, following the same system of classification as before, namely, taking a staff with 3 inch intervals marked and numbered serially, and using this for assigning each tree to its class number.

Before discussing these measurements, it will be necessary to present the history as regards rainfall, since this has undoubtedly been the ruling factor in growth. It may be recalled that the soil is very porous and sandy, so that the young plants suffer badly during dry weather. The diagram shown in Figure I indicates the weekly totals of rainfall since Block 6 was planted. The figures actually refer to the gauge at the Laboratory, which is some 8 miles from the Experiment Station. These figures had to be used, since figures at the Experiment Station were not available for the first part of the period. As shown in another note in this issue there can be no doubt that the figures used give an accurate idea of the seasonal variations, although the totals differ considerably.

The period since planting falls into five distinct intervals. (1) The wet planting season lasting until the end of December 1928. This was followed by (2) very dry weather in January, February and part of March. April and May form (3) a second wet interval followed again by (4) a long dry interval which broke at the end of September with the onset of (5) the next planting season. The measurements here described were taken at a time when the second manuring, as well as the third wet period, would have had time to produce marked results.

It was remarked in the first report that the size distribution curve showed a curious flatness. In this second series the reason for this result emerges more clearly. A closer analysis reveals that the curves show prominent peaks indicating that the trees fall into several distinct groups. The separation between these groups has been increased by the further period of growth. They can be traced in the first series but were not distinct enough at that time to cause comment. As an instance, the distribution curve for the control

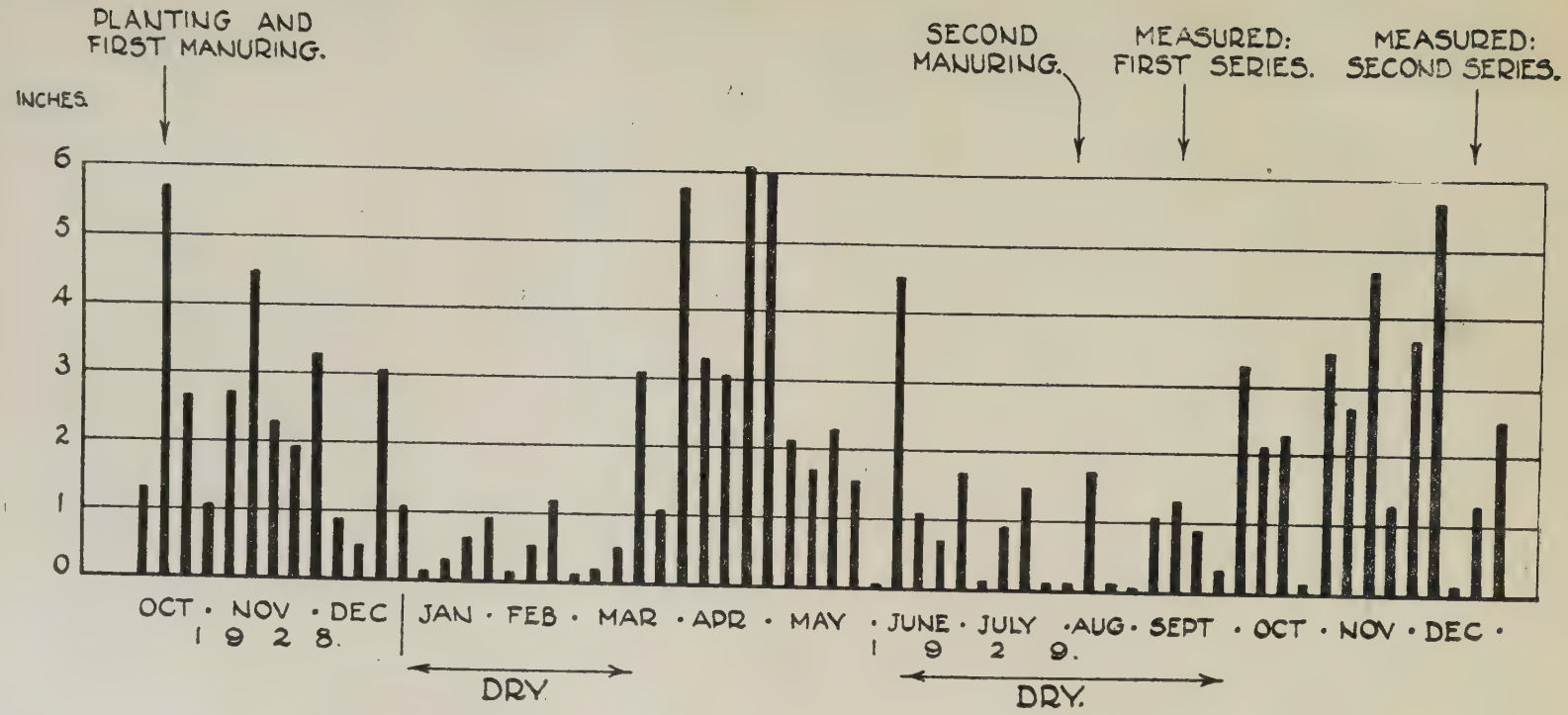

Fig: 1.

RAINFALL — WEEKLY TOTALS.

plots A is shown in Figure 2 in continuous line. There are three distinct groups having mean values of 2 ft. 9 ins., 6 ft. 6 ins. and 9 ft. 6 ins. respectively. It is suggested that these groups have been formed as a result of the retardment of growth during dry seasons acting differentially upon the trees according to size. Such an explanation involves the supposition that there is a critical size (of the tree in general and of the root in particular) beyond which the tree largely escapes the effect of drought, but below which there is definite retardation. Then the largest group will correspond to those trees which extended their root systems far enough during the actual planting season to escape in a large measure the checking influence of the ensuing dry period. The middle group would correspond to those trees which passed the critical stage during the second wet season, while the first group, which is common to all plots, represents those trees which even at the time of measurement had not passed the critical stage. The curve shown in broken line in Figure 2 shows similar groups for the D plots (which receive Nitrogen only).

Figure 3 is the distribution curve for the total population, which shows two distinct classes only, since the differences between plots due to manuring have caused the two larger groups to merge together. At the time of writing (January 1930) the division into two size classes is very noticeable to the eye and makes the stand of trees appear extraordinarily irregular.

A large number of stunted trees are affected with *Fomes Lignosus* and are being supplied. It remains to be seen from further examination to what extent disease and drought have been inter-related in keeping back the smaller class. When a stump is attacked before it has started vigorous growth, this fungus does not kill quickly but gives rise to a prolonged sickly stage accompanied by arrestment of growth. The groupings can therefore be subdivided, and such analysis gives rise to one or two very interesting inferences.

The smallest group containing the failures may be taken as below No. 9 (equals 2 feet). Very few of these were missing or dead, but no progress had been made after the first shooting. Their distribution among the various plots is as follows:—

Plots A—11, Plots B—23, Plots C—24, Plots D—16, Plots E—15, Plots F—20. These figures indicate that the control plots A had decidedly the smallest number of failures. An explanation of this would seem to be that the manuring rather increased the incidence of disease attack as affecting the plants immediately after planting. The causal organism would naturally be stimulated by the addition of the plant foods in the neighbourhood of the plant roots. It should be noted that 20 failures in one set of plots only represent about 4 per cent. of the trees.

The next group might be called the " stagnant class," that is, those trees which have not yet (or only recently) started to 'get away'

DISTRIBUTION CURVES.

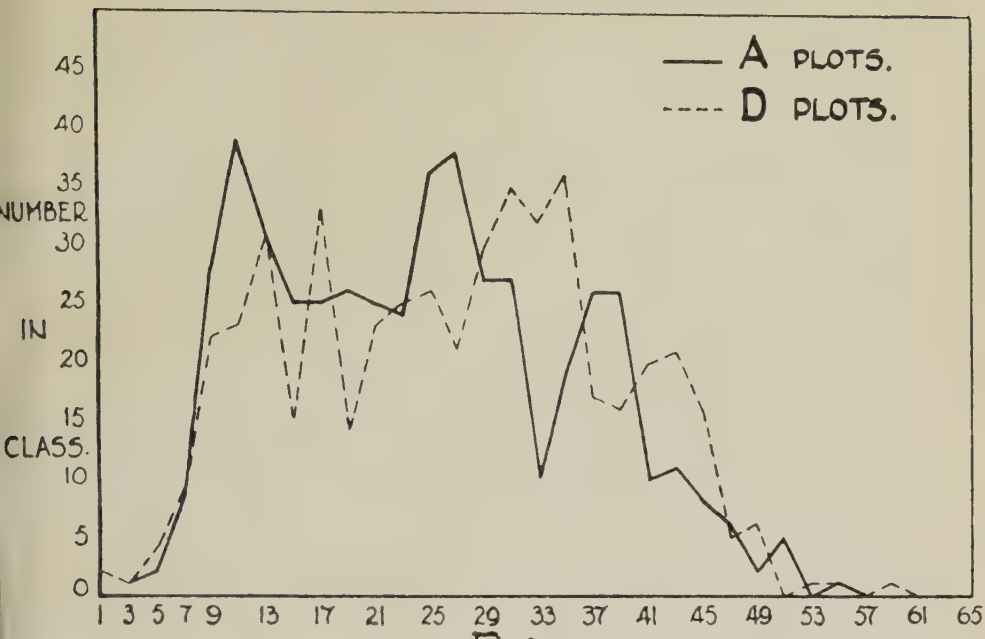

Fig: 2.

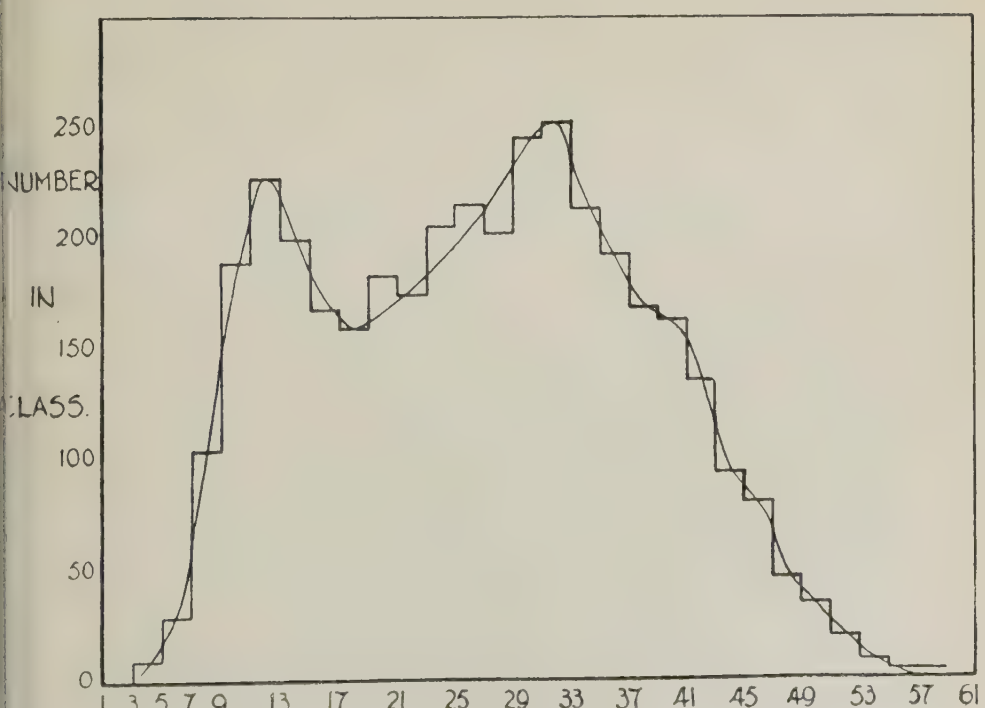

Fig: 3.

as regards growth. Taking the upper limit of this class at number 19 we have the following total numbers between 9 and 19. Plots A—148, Plots B—108, Plots C—129, Plots D—124, Plots E—129, Plots F—105.

The figure for the control plots A is the greatest, although it was the least in the last group. Expressed in a different way this signifies that the number of escapes from the 'stagnant class' for all manured plots is greater than for the control. The average size of tree in this sub-group were, for different treatments, as follows:—

A—3.4 ft. B—6.0 ft. D—3.6 ft. E—3.4 ft. F—3.6 ft. Here it is the B plots (dung) which stand out from the rest. The greater average height for this plot is accompanied by a less distinct splitting off of this class from the other: but the inference is legitimate that young plants struggling against a heavy handicap (root disease, etc. in conjunction with drought) make better headway when an organic fertiliser has been given than they do under treatments from chemical fertilisers.

Leaving the main size group for the moment we may next deal with the 'most favoured' or largest class, which may be supposed to be composed of those trees which established themselves thoroughly in the season of planting. They are almost 50 per cent. larger than the main group. The separation from the main group is most distinct for the A, B and D plots and the mean size attained runs in that order, namely A—9′6″, B—10′3″, D—11′0″. This order also corresponds to the amount of nitrogen received. For the C, E and F plots, the splitting off of this class is not to be remarked. The division at this point is attributed to the effects of the first dry season, separating two groups, one of which broke away in the planting season and the other in the next wet season. There is therefore an indication of some drought-resistant effect in treatments C, E and F which is absent from A, B and D. This must be something other than nitrogen, and the constituent which C, E and F received in common was superphosphate. Part of the action might be attributed to the calcium in this fertiliser. We have evidence that this element is far more deficient than phosphorus as regards availability in this particular soil. That this distinction between these two groups of plots is not due to chance is confirmed by the fact that when the plots were taken grouped into 'rows' and 'columns' (each group of six then having one plot of each treatment) none of the distribution curves showed a splitting off at the largest group.

Taking the main size group and estimating the mean size from the curves, the following values are obtained:—

A 6′6″ B 7′6″ C 8′0″ D 8′8″ E 8′0″ F 7′9″

This comparison is possibly the best that can be derived from the figures as expressing the effect which is to be expected from the manures without the exceptional disturbing effects which have already

been discussed. It represents a benefit of from 15 to 20 per cent. which is of the same order as the increase remarked in the " most favoured " class. As the later analysis will show, the results when referred to grand totals are less than this, being weighted by what is in effect an unresponsive class. It may be remarked that the increases are for one year only, and that future benefits may be expected, at least for some time, to accrue according to "compound interest" rather than "simple interest" laws.

TABLE I.

Height totals for plots according to position in field.

						Totals.
E 2028	A 1979	B 1949	F 2340	D 2265	C 2250	12811
F 1961	B 1807	D 1894	E 2261	C 2707	A 2260	12890
D 2342	E 1983	A 1906	C 1893	F 2170	B 2725	13019
C 1748	F 1925	E 1924	A 1867	B 2306	D 2614	12379
A 1848	D 1946	C 2273	B 2107	E 2329	F 2227	12730
B 2112	C 1801	F 2296	D 2104	A 2358	E 2316	12987
Totals 12034	11441	12242	12572	14185	14392	76816

TABLE II.

Height totals for plots according to treatments.

A	B	C	D	E	F
1979	1949	2250	2265	2028	2340
2260	1807	2707	1894	2261	1961
1906	2725	1893	2342	1983	2170
1867	2306	1743	2614	1924	1925
1848	2107	2273	1946	2329	2227
2358	2112	1801	2104	2316	2296
Totals 12218	13006	12667	13165	12341	12919

In Table I is given the results of the census expressed as the totals of the height numbers for each plot, the positions in the table corresponding to the positions in the field. It is evident that the two series of plots nearest the road, which correspond to the two columns on the right of the table, are in a favoured position relative to the rest. Table II gives the data of Table I re-arranged according to treatments.

The mean values for each treatment from Table II can be expressed as percentages, as follows:—

A 100 B 107.1 C 103.6 D 107.9 E 105.8 F 105.9

The total effect so expressed is not large. It remains to test its significance. The discussion of the analysis of variance for the "Latin-square" layout, followed in this experiment, is given by Dr. R. A. Fisher in his book " Statistical Methods for Research Workers." Applying the calculation to the above figures (without reference to any small disturbing effects the "mixed" nature of the population may have on the plot totals) we obtain the following table.

TABLE III.

	Degrees of Freedom	Sum of Squares
Rows ...	5	45,526
Columns ...	5	1,185,623
Treatments ...	5	91,312
Remainder ...	20	843,593
	35	2,166,055

This gives a standard error of 3.9 per cent. for the experiment. The differences shown for the effects of manuring are between one and two times the standard error. Thus, although every treatment appears to show an increase, the level of significance is low.

Since this record is one of a series, and will, therefore, receive further light from later developments, it is not proposed at present to examine this set of measurements more exhaustively.

NOTE ON RAINFALL DISTRIBUTION.

BY

W. B. Haines.

It is a matter of common observation that a large proportion of the rainfall in Malaya is of a very local character. The commonest type of rain starts in the hills as a series of isolated centres which move off across country. There appears to be good evidence to suggest that these showers tend to move more often along certain routes than along others, causing considerable local variations in rainfall. Even within the same town it has been suggested that this may give rise to areas which show better results for gardening, because their situation gives a better chance of a shower during periods of scarcity when rain is most needed.

In the following table is given an interesting comparison afforded by the two recording stations of the Rubber Research Institute which are about eight and a half miles apart, the first at the Laboratory, Bungsar Estate, Kuala Lumpur, and the second on the new clearing in the Sungei Buloh Forest Reserve. The figures shown are the weekly totals from the beginning of June (when records at the Experiment Station began) to the end of December 1929.

TABLE OF RAINFALL—WEEKLY TOTAL IN INCHES.

	Bungsar: Laboratory		Sungei Buloh: Experiment Station			
	Rain inches	No. of rain days	Rain inches	No. of rain days		Difference in inches
June ...	4·57	3	7·90	4	+	3·33
	1.13	4	3.20	4	+	2.07
	.63	4	1.76	3	+	1.13
	1.66	2	2.60	5	+	.94
July ...	.09	1	.80	3	+	.71
	.94	3	.22	3	—	.72
	1.43	2	1.01	5	—	.42
	.05	1	.03	2	—	.02
	.01	1	.23	4	+	.22
August ...	1.79	4	2.08	5	+	.29
	.17	2	.01	1	—	.16
	.04	2	.45	1	+	.41
September ...	1.03	1	.96	4	—	.07
	1.34	4	1.09	4	—	.25
	.87	4	1.66	6	+	.79
	·33	3	2.43	6	+	2.10
	3·34	7	6.85	7	+	3·51

		Bungsar : Laboratory		Sungei Buloh : Experiment Station			
		Rain inches	No. of rain days	Rain inches	No. of rain days		Difference in inches
October	...	2.18	5	2.63	5	+	.45
		2.25	4	4.81	5	+	2.56
		.11	2	.97	5	+	.86
		3.54	6	6.22	7	+	2.68
November	...	2.69	6	4.74	6	+	2.05
		4.78	7	3.41	7	—	1.37
		1.23	5	4.43	6	+	3.20
		3.69	4	4.44	6	+	.75
December	...	5.65	4	5.55	7	—	.10
		.08	2	.75	6	+	.67
		1.29	3	.35	2	—	.94
		2.47	6	2.35	5	—	.12
		.44	1	2.77	5	+	2.33
Totals	...	49.82	103	76.70	139		26.88

The Table makes it very evident that the Experiment Station is more favoured as regards rain, receiving a total which is more than half as much again as that received at the Laboratory site. What is more important, the distribution in time is better, as shown by the greater number of days on which rain was recorded. At the same time it is to be noted that the seasonal distinctions between periods of high rainfall and of low rainfall, are rather more marked at the Experiment Station than at the Laboratory. The Government Meteorological Station at Railway Hill, Kuala Lumpur, is just under two miles from the Laboratory. A comparison of these two series of records showed only a slight and scarcely significant difference in favour of Railway Hill (both as regards total amount and number of rain days).

It would be of great interest if further comparisons of this nature could be made available. The co-operation of estates in making returns, particularly in those areas which are practically completely covered by rubber estates, would provide material for some very interesting studies. It appears not unlikely that some estates may be handicapped as regards rainfall even when compared with their near neighbours, or even that areas on the same estate may show marked differences from one another from this cause.

TAPPING RESULTS & OTHER OBSERVATIONS ON SEEDLING CROSSES OF HEVEA IN SUMATRA.

A long and interesting paper by Dr. C. Heusser in the September number of the Archief voor der Rubber Cultuur (pp. 495 to 530 in Dutch with an English translation, pp. 531—534, which unfortunately contains a few printers' errors in the summary) contains the results of three years' tapping of a large group of seedling crosses with observations on the inheritance of a number of secondary characters, and also throws light on a number of points on the development of seedlings in general.

In the following summary it is possible to quote particulars only of the crosses that best illustrate the main points. Details of the remainder must be sought in the original by those who have a special interest in any individual clone or cross.

The crosses were made in 1920 and the seeds planted in nurseries. From October 1921 to January 1922 the seedlings, roughly one year old, were planted out as stumps at Sungei Pantjoer after most had been marcotted. In addition a few seedlings of 1919 crosses were transplanted, making a total of 1691 stumps belonging to 30 different combinations of 17 mother trees (which gave from 30 to 80 gms. per tapping in 1919 at about 12 years old).

Owing to root disease and partly on account of unsuccessful plants 15 per cent. were lost in the first year. At the end of the second tapping year 1450 plants were left and 1393 or 96 per cent. of these were in tapping.

The plantation when taken over was overgrown with lalang and is reported to have grown tobacco 20 years before.

After cleaning, *Mimosa invisa* was planted between the rows and later the area was silt pitted and *Vigna* and *Centrosema pubescens* planted and ring weeding was carried out.

The crosses were planted in blocks at a distance of 7 metres (23 ft.) square to allow the trees to develop freely.

Tapping was started in Nov. 1925, 4 years after planting out the stumps, on trees with a girth of 40 cm. at one metre. Others were added later as they reached this size and so the comparison of merely the best trees of the family was avoided. The first tapping panel was opened with a 30° left handed cut over half the circumference at 50 cm. (20 ins.), and at the beginning of the 2nd year all trees were changed to a $\frac{1}{3}$rd cut at 75 cm. The trees were tapped in alternate months—some rows of trees in the odd months, and the others in the even. With no Sunday tapping there were 150—155 tapping days a year. Bark consumption was limited to $1\frac{3}{4}$ ins. per tapping period and amounted to about 10 ins. per year.

The latex was coagulated in the cups and the biscuits for the month creped, dried, and weighed, and the average yield per tapping calculated.

As the yield recording gave additional work the tapping task was set at 150—200 trees and the tappers were moved from task to task in regular succession each day.

II. Tapping Results.

The following table (extracted from Heusser's table II) summarises the yields of all the crosses, and gives a rough comparison with normal estate yields for Sumatra.

TABLE I.

Tapping Years.	Crosses.			Normal Estate Seedlings		
	1st.	2nd.	3rd.	1st.	2nd.	3rd.
Yield lbs. per acre	119	371	439	112	224	313
No. of trees tapped per acre	58	61	65	69	81	93
Yield per tapping gms.	7.8	18.6	20.2	5.7	7.8	9.5

The yields of 28 unselected stumps in the experimental garden were less than one-half those of the crosses.

Thus even allowing for greater care and the wider planting distance " the higher yield per hectare is so great that the beneficial influence of selection cannot be disregarded." [It must be remembered however that both parents were selected. L.E.M.]

The decrease in the monthly yields due to wintering was less pronounced in the first two years than in the third year.

The reduction in yield due to changing to the new tapping panel is estimated at 37 per cent.

Yield of the Various Families.

There are big differences between the yields of the various families.

One striking result is that all the families with tree 157 as one parent, either male or female, are amongst the best: they averaged 28.5 grammes per tapping in the third year. The 145 families are the poorest with a mean yield in the third year of 15.9 grammes.

From a mathematical comparison of yield between groups of families with a common parent the mother trees can be arranged in order of value. Of those on Bandar Klippar 157 is the best; 161, 164, 151 and 165 are almost equal; 166 and 142 are not so good. The best Tjinta Radja tree is 138; 38, 146 and possibly 49 are almost equally good; and 149, 139 and 146 are bad.

Marked differences are shown between the annual percentage increases of yield. For example the yield of 166 × 164 increased by 200 per cent. from the 1st to the 2nd tapping year and then by 49 per cent. from the 2nd to the 3rd, 138 × 146 showed an increase of 154 per cent. and a decrease of 4 per cent. respectively, and 157 × 151 increased by 118 per cent. and then by 10 per cent. These differences probably are due to a different development of yielding power with age, and also to variation in the dependence of yield on the height of the tapping cut. Heusser concludes that "for selection purposes therefore the first tapping year cannot give a true aspect of the quality of the families, and true conclusions must be based upon several years' observations."

As the object of artificial pollination is eventually to get pure strains, the study of variation is important. With Hevea yielding ability probably is determined by a number of hereditary factors and therefore low variation can be taken as an indication of the purity of the family.

The degree of variation varies from family to family, for example the coefficient of variation (i.e. the standard deviation expressed as a percentage of the mean) for the three years' average yields is 34.5 per cent. for family 145 × 138 and only 19.0 per cent. for 138 × 139. All the 157 families are noteworthy for the symmetrical distribution of the individual tree yields about the mean.

It is not possible to make a strict comparison between the relative yields of mother trees and their clones and seedling families but it does appear that the best clones and seedling families do not necessarily come from the same mother trees, owing to the action of environment on the expression of hereditary characters. Dominant characters and environment determine the yield of the mother tree and its buddings, but the recessive (latent or dormant) characters can appear in the hybrid seedlings and give very different results. A mother tree may give bad buddings and good seedlings or *vice versa*, and both may be good or bad.

The monthly tapping figures of the 70 (5 per cent.) best individual seedlings given in Heusser's Table 8 show that considerable changes took place in the relative performance in the three tapping years. In illustration of this the yields of the seedlings that gave the

highest yields in the first, second and third years are set out in Table II below:—

TABLE II.

Best Tree in	No.	Cross.	——	1st yr.	2nd yr.	3rd yr.	Mean.
1st year	274	49 x 26	Yield gms.	24.5	48.8	34.4	35.9
			Order	1	8	145	22
2nd ,,	275	142 x 157	Yield gms.	19.5	58.4	43	40.3
			Order	9	1	59	8
3rd ,, (& all 3)	317	165 x 161	Yield gms.	11.7	50.4	91.9	51.3
			Order	*	7	1	1

* = below best 10 per cent.

Thus for individuals as for families, changes occur from year to year and the saying " good trees remain good " cannot be used in selection work, although it applies for practical thinning out.

III. Secondary Characters.

Although the production of rubber is the principal consideration in judging the trees, the secondary characters such as growth vigour, bark thickness, etc., cannot be ignored. It has been shown that these are largely hereditary but it is necessary to wait for at least a second generation to understand the method of transmission, which characters are dominant and so on.

Girth.

Measurements of girth give a good comparison of growth development of the trees. It appears generally speaking that the more strongly growing families were obtained from the better developed mother trees. The crosses 49 x 26 and 138 x 49 show the thickest trees, and most of the offspring of 164, 166 and 140 are of small girth.

Within the families the correlation between girth and yield is very slight, and even in the uniform family 157 x 164 the co-efficient is only 0.305 ± 0.014. Even so a well grown tree is to be regarded as more desirable than a feeble or thin one.

Bark Thickness.

Bark thickness appears to be hereditary, and the trees with the thickest bark belong principally to the families of 161 and 49, the bark measurements of which were above the average for the mother trees.

There appears to be a fair correlation between bark thickness and yield but it has not been evaluated so far.

Brown Bast.

At the end of the 2nd and 3rd years 4 per cent. of the trees were found to be suffering from brown bast, which is the same proportion as found in actual practice with the same tapping system. Only 6 trees were taken out of tapping owing to heavy attacks.

With one exception the highest yielding families suffered most severely from brown bast. The families with 164 and 161 as one parent were all badly diseased and, in 164 × 161, 21 per cent. of the trees were attacked. In this family considerable wood formation took place in the affected bark.

Other families of 36, 138, 146 also showed the disorder but it cannot be said which parent has the greater tendency. As brown bast did not appear in trees 161, 164 and 36 until 1921 and 1922, that is after pollination was carried out, it can be stated that susceptibility to brown bast is hereditary. Thus though there is a danger of cultivating seedlings or clones with this character there is also the possibility of eliminating it by careful breeding.

Tree Shape and Tendency towards Breaking.

In order to permit free development of their characteristic branching the crosses were widely spaced. Usually the seedlings of a family display striking uniformity of habit, and sometimes the peculiar characters of the parents are recognisable in their offspring. For example, the offspring of 49 in their second year form small crowns with right-angled branches, which later often become as strong or stronger than the main stem and this frequently ceases to grow. Thus the trees develop the typical bowl shaped crown and irregular branching characteristic of the mother tree and clone 49.

The seedlings of 36 are more liable to wind damage than the others owing to the acute-angled branching, the heavy crown and brittle wood. The influence of the strength of the wood apart from the branching habit is shown in the family 145 x 36 by some seedlings that are subject to wind damage in spite of the ideal lamp post branching they have inherited from 145.

Bark Renewal.

Bark renewal is very satisfactory for all the crosses and particularly so with the well developed trees.

Leaf Fall & Flowering.

The families show a striking coincidence in the time of wintering and flowering, and they can be arranged in the following groups:—

1. Early wintering: 157.
2. Average early wintering: 164, 165, 166, 36, 140, 141.
3. Late wintering: 151, 142, 138, 139, 26, 145, 161.
4. Flowering, but no complete wintering so far: 49.

Fertility.

Strong evidence that fertility, subject to external influences, is hereditary is given by the crosses between 164, a prolific seed bearer, and 161, which so far has produced very little seed. Except for the cross 164 x 161 all the other seedlings of 164 are good seed producers. As the number of seeds per tree is comparatively small in Hevea, the fertility character is important in breeding work.

Seed and Leaf Shape.

The leaves and seed of the seedlings are often strikingly similar to those of their parents, some resemble more closely the father and some the mother.

The seeds of some of the trees of 138 x 49 are very difficult to distinguish from those of 49. The seeds of 49 x 26 mainly possess the colour and markings of 49 with the large round shape of 26.

The leaves of most of the seedlings of the family 164 x 161 have the round broad tip of 161, while amongst the offspring of 151 its long pointed shape predominates.

No relationship could be found between yield and the quantity of leaves and seeds.

Backward Trees.

At the end of 1927 20 per cent. of the trees of the family 138 x 146 were backward. The leaves are yellowish green, wintering was premature and the stems mainly are crooked. As the trees are spread through the whole block this cannot be attributed to their situation and can be regarded as a character inherited from 138. The crosses of 145 were also backward to a smaller extent.

Formation of Cork.

The formation of an abnormally thick layer of cork must also be regarded as an hereditary character. It is particularly common in the progeny of 145, 138 and 164. In the family of 145 x 138

82 per cent. of the trees have coarse bark and both the mother trees and their buddings also display this character. Other families from these parents show from 26 to 43 per cent. of cork bark trees, which appear only sporadically in the remaining crosses.

Yellow Foliage.

The family 166 x 161 contains a number of trees with golden yellow to greenish yellow foliage. This character however is not detrimental to yield, and two trees of the family are amongst the best 2 or 3 per cent. of all the crosses.

Germinating Plants with no Green Leaves.

Several germinating seedlings of 145 x 139 and 138 x 139 had white leaves and died off on planting out. This character apparently comes from 139.

Fasciations.

A number of 164 seedlings developed fasciations when about one year old.

Discussion.

Although the results show that higher yielders have been obtained in the first generation the selection problem has not been simplified, and one cannot prophesy the behaviour of the seedlings from the yield of the mother trees.

Further seed selection will be carried on from families that are uniform as well as high yielding. New clones will be started from those families with high individual yields and a high family average, although for this purpose uniformity is secondary it should be considered as well, for the new clones may be valuable for seed as well as yield.

The most promising type for continued selection is 157. Already new crosses have been made to introduce more growing power and resistance to brown bast in addition to increasing the production, both from the old mother trees and from various members of the families of crosses that possess the desired characteristics.

The 161 families are a promising group for clonal selection but their variability is rather great for seed selection.

As one is limited to a small number of trees for seed selection and breeding, it is apparent that an endeavour must be made to increase the number of trees per family, for the results of experiments on a small number of seedlings can be regarded only as preliminary.

V. Conclusion.

On an average the seedlings have not yielded as well as the best clones, but as the yield of an area of seedlings can be increased by selective thinning then seed from crosses of 157 can be regarded as equal in value to buddings. In time when seed from seed gardens becomes available the slogan "buddings versus seedlings" will be changed into "seedlings and buddings."

L.E.M.

INSTRUCTIONS FOR SENDING PLANTS FOR IDENTIFICATION.

During the past two years a number of specimens of cover plants and weeds has been sent to the Institute for identification and advice, but it has happened fairly frequently that the specimens have been in poor condition, or not sufficient to allow of complete identification.

The following instructions are given therefore to prevent disappointment to the sender, and to avoid waste of time in unsatisfactory attempts at identification.

The classification of plants depends in the first place on differences in their reproductive systems, while differences in vegetative characters—leaf shape, etc. are involved only in the separation of closely allied species. It is essential then that specimens for identification should be complete plants or, if these are too large, should be representative of all parts of the plant.

Flowering Plants.

Specimens of flowering plants should include leaves, stem, flowers, and mature fruits whenever possible. Often a little search will reveal these, even out of the general flowering season. A note should be made of the colour of the living flower as this often fades badly during transit to the Institute.

Ferns and their Allies.

Specimens of ferns should be complete fronds, including the base of the stalk, in the reproductive stage, if possible. With a little trouble it is usually possible to find a few plants bearing sporangia—in brown lines or spots—generally on the under surface of the leaves. but sometimes, as in stag mosses, etc., on special leaves or specially developed parts of the ordinary shoots, usually towards the tips, and these parts should be included.

Where advice is sought on the suitability of naturally occurring plants for use as covers it is important to include the root system as well, or to make a note of its character, whether shallow or deep, and so on. The conditions under which the plant is growing should also be mentioned—in a new clearing, on flat land, in a swampy area, on peaty soil, etc.

Plants should be packed and despatched immediately after collection. They may be placed between sheets of non glazed paper such as blotting-or newspaper rolled up or kept flat by a piece of cardboard. Ripe fruits should be wrapped to avoid loss of seeds on drying.

The packet must be addressed to the Director, Rubber Research Institute of Malaya, and to avoid confusion and delay should bear the name of the estate of origin—especially where the covering letter is sent separately.

L.E.M.

EDITORIAL.

A new feature in the Quarterly Journal which, it is hoped, will serve a useful purpose is the publication of an editorial drawing attention to the principal points in the various articles published and to any other matters of special interest to the rubber planting community in Malaya.

Oidium Leaf Disease.

In view of the recent outbreak of secondary leaf-fall caused by the Mildew fungus—*Oidium Heveae*—in several large areas in Malaya, the article contained in the previous issue of this journal (Quarterly Journal Vol. 2 No. 1, 1930) was published at an opportune time. The present issue contains an article by Mr. F. Beeley who was sent to investigate and report on the recent outbreak.

Although Oidium disease was first reported in Malaya in 1925 by A. Sharples, Mycologist, Department of Agriculture, S.S. & F.M.S. (Vide Malayan Agricultural Journal Vol. XIV No. 4 1926), the recent outbreak was the most severe so far experienced in this country.

As is indicated in the article the drought conditions during the re-foliation period, after the normal leaf-fall due to "wintering," are considered to be responsible for the severity of the attack. The trees recovered rapidly as soon as the rains came, although it is not possible to state what effect this secondary leaf-fall may have on the yield of latex in the affected areas.

It is extremely probable that, owing to the effect on the flowers which appear at this period, there will be a considerable reduction in seed production during the next seeding season.

Steps had already been taken early in the year to purchase sprayers and dusters for experimental work in connection with possible outbreaks of leaf-disease.

Data in connection with the cost of sulphur dusting in Java and Ceylon are also published in this journal as a guide for Malayan practice. Neither in Java nor in Ceylon have the control measures already adopted proved entirely successful and further investigations are being pursued.

In view of the more widespread and general occurrence of the disease in Java and Ceylon, the work carried out in those countries will be followed closely.

Attention is also drawn to the regulations which appeared in the F.M.S. and S.S. Government Gazettes making the disease notifiable.

If the disease is suspected, specimens of the affected leaves, flowers, etc. should also be forwarded to this Institute for examination.

Manurial Experiments.

Many manurial and other field experiments particularly on permanent crops such as rubber have been laid down previously in such a manner as to provide insufficient or unsatisfactory data on the effect of the treatments applied.

It has been realised for some time that, in order to allow for field variations of several kinds, such as variation in soil, variation in the planting material and climatic conditions, and to be able to estimate the probable error of such field experiments and thus to realise the effect due to the treatment applied, it is essential to lay out field experiments on such lines that the data obtained can be subjected to statistical treatment.

The article on "Manuring (II) Technique of Plot Experimentation" by Dr. Haines, Head of the Soils Division, which should be read in conjunction with Manuring of Rubber (I), published in the Quarterly Journal Vol. 1 Nos. 1 and 2, page 98, contains details of the methods and lay-out which should be adopted in manurial trials or other similar treatments designed to give results of a known degree of accuracy.

Since it is realised, however, that it is not possible on all estates to conduct such experiments by the ideal methods, more simple lay-outs of trial blocks are also described.

Smoking of Rubber and Fuel Consumption.

In 1924 at the request of Sir W. George Maxwell, K.B.E., then Chief Secretary to Government, F.M.S., an article was published in the Malayan Agricultural Journal (Vol. XII Nos. 6 & 7) entitled "The Utilisation and Waste of Wood in the Preparation and Packing of Raw Rubber." In the rubber producing countries of the Far East, particularly in Java and Ceylon, with a long history of previous cultivation under other crops and the consequent destruction of the forests, the problem of the supply of wood as fuel for the smoke-drying of rubber is becoming more acute. Even on some estates in Malaya wood has to be purchased for the smoking of rubber.

Although investigations are in progress in Ceylon and Malaya in particular with the object of preparing a type of rubber for the market as a substitute for smoked sheet, it has been considered advisable to obtain data from estates of the amount of wood fuel per unit weight of dry rubber consumed in the smoking process. The results of a questionnaire sent to fifty estates have been collected and analysed

by Mr. R. G. Fullerton and are published in this journal. On the whole, compared with results obtained by a similar questionnaire in Java, the summary of which is also given, the Malayan figures are very favourable.

It is intended later to obtain further data by issuing the questionnaire to other estates producing smoked sheet, of which about 150 are at present known. Any estate Manager who is willing to supply information is invited to apply to the Institute for a copy of the questionnaire.

Rubber Research In Ceylon.

An abstract of the activities of the Rubber Research Scheme of Ceylon during 1929 is published, so that the rubber planting community in Malaya is kept in touch with matters of interest in relation to rubber cultivation, preparation, etc. in that country.

Second Imperial Mycological Conference.

In view of the importance of diseases of the rubber tree, several matters of interest including resolutions adopted at this Conference concerning Malaya and other eastern rubber planting countries are published.

MANURING OF RUBBER—II.*

TECHNIQUE OF PLOT EXPERIMENTATION.

BY

W. B. Haines.

Owing to the very variable results which have so far been obtained from the manuring of old stands of rubber it is evident that a further long period of experimentation must elapse before the data are sufficient for a proper elucidation of the different factors that are at work. In order to cover varieties of soil and varying age-class of trees it will be necessary that such experiments be conducted on different estates. It is the purpose of this article to indicate, for the assistance of estates, the more important points in the design and carrying out of field experiments in rubber. Experiments may fail through want of care in recording or lack of continuity in their conduct, but much more frequently the failure of an experiment to provide conclusive figures can be attributed to want of knowledge in designing the original plan. No amount of care and accuracy can increase the value of an experiment which has not been properly planned in the first instance.

Any kind of controlled treatment that affects a crop may be made the subject of a field experiment. The only essential is the provision of such plots as will give a legitimate comparison between areas which receive the treatment and those which do not. Although the applications of fertilisers in various combinations and various amounts are the treatments that are most usually under test, treatments of other kinds are equally susceptible of examination by experiment. All debated points regarding the effects of covers, drainage, silt-pitting, methods of tapping, and so on, are far better referred to the test of experiment than to the judgment of the theorist. The point most usually overlooked is the provision of the untreated or control area to give a basis of reliable comparison. In rubber cultivation, it has been usual for any estate to pin its faith to a particular practice and to apply it to the entire area. Such an experiment is "out of control" in the sense that results are left to guess-work for want of a standard of comparison. Guess-work may be shrewd and well-informed, but the scientific and direct approach is quicker and more sure. If, in the past, control plots had been left in cases where a difference of opinion was possible, or other side-by-side comparisons

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made of different treatments, estate practice would now be more advanced by the accumulation of reliable information on points at issue.

The comparisons afforded by experimental plots have most usually to be reduced to a series of numbers by means of some method of measurement (in rubber, measurement of yield, height, girth or bark thickness) in order that accuracy may be attained. A numerical statement is, in any case, a concise and convenient method, although its interpretation will usually require some contribution from personal judgment. There will always remain, in any field experiment, factors which are ponderable to intelligent judgment but not susceptible of exact numerical measurement. It has often been the experience during the first years of manuring a field of rubber that there is great improvement in appearance but no recorded improvement in yield. Although the statistical result is nil, the subsidiary observations in such a case prevent one from delivering a negative verdict, and call rather for a suspension of judgment till a later date.

Scientific design aims at bringing every point possible concerning an experiment within the range of analytical methods applied to the numerical results. In some cases, indeed, the results of a treatment may be so striking that no close analysis is required to prove its value; for instance, a fifteen-times increase in a tomato crop was produced by the use of manganese on certain American calcareous soils. A mere glimpse of such a field experiment without any measurements would suffice to establish the practical conclusion. Or again, the cost of a treatment may be so large that unless the result is striking it can be at once rejected without closer analysis. But, as a general rule, the cost of the treatment on the one hand, and the definite return which it gives on the other, are so nearly balanced that only a careful analysis of the results can properly decide the practical issue; that is, whether to adopt the proposed treatment on an extensive scale or to reject it.

The requirements to be met by the method of laying out plots can best be approached by considering what we wish to do with the figures obtained finally as an expression of the result. Suppose that we have the yield figures from two plots of rubber, one of which has received a certain fertiliser and the other has been left as a control. The difference between the two yields cannot be attributed to the fertiliser *alone*, since a variety of other causes may have produced effects which are not equal in the two plots. For instance, every planter is familiar with the better conditions shown by a plot near the bottom of a slope, down which the soil has been washed. The particular factor whose effect on the yields it is required to assess is the manuring, but, before this can be accurately arrived at, it must be possible either to eliminate or at least evaluate the effects which may be put down to all other causes together (such

as effect of location, personal skill of the tappers, chance differences in the time of tapping, and so on). It is not enough to know that a certain disturbing influence exists. It must be removed or spread equally over all the plots if such adjustment is possible, or it must be allowed for by some reliable means of estimation if it is beyond all control. As an example one may quote the case of a series of manured plots of rubber in Ceylon which have been carried on for many years, the results of which are impossible of precise interpretation because the control plot is known to have a great advantage as regards position; this is the only control and so there are no means of estimating a correction. The best plot has sometimes been deliberately chosen as control in experimenting, on the assumption, apparently, that artificial treatments must be expected to outweigh entirely the differences due to natural advantages. Such reasoning and methods are obviously not sufficiently judicial.

The requirement of a valid experiment then is that the results shall fairly prove that the differences observed are due, not to chance advantages which the plots have enjoyed, but to the treatment under test. For the comparison of two plots only, it would be necessary first to prove that the two plots were absolutely uniform in all other respects before the difference in yield could be attributed with certainty to the manuring. Now uniformity cannot be proved nor tested for without taking a fair number of samples (or plots). Hence the requirement which we are considering is met by providing exact repetitions of the plots. Then the particular treatment remains the one controlled and constant factor throughout the repetitions, while the effects of the other factors may be estimated by comparing the various figures for plots of like treatment (whether controls or treated). The mistake is sometimes made of increasing the number of kinds of treatment with the number of plots, so that it is necessary to state that the repetitions should be identical in every controlled factor. The differences between the plots which have the same treatment provide a means of estimating the variation which has been produced by unknown and uncontrolled causes. This variation is called the error of the experiment, and it is plain that a difference between treated and untreated plots is not valid for a clear inference that it is a result of the treatment, unless it is much larger than the error. Such a comparison with the error allows one to state what is called the "significance" of the result. In mathematical terms it reduces to a statement of a probability, i.e. a statement that a result such as that given would be arrived at by chance once in so many times.

For an experimental increase of a given amount the significance will be the greater the smaller the error of the experiment. A scientific field experiment must therefore be so arranged that the error can be assessed accurately and also reduced to the smallest

possible value. One might here use the analogy of a net which is being used to examine the fish in a pond, extracting them by straining the whole contents through it. The practical person who required the fish for food and had no need for small fry would be content with a fairly wide mesh, but a naturalist who wanted the greatest variety of specimens would use the finest mesh possible. In the same way the "error" of an experiment determines the size of mesh through which the results are to be strained or tested. If the error is too large compared with the experimental difference, then these results pass through and no reliable conclusion can be garnered. Conversely, the smaller the error the more reliable the experiment becomes for scientific interpretation. Reduction of the error depends upon care and elaboration. But one is guessing in the dark until the error (or size of mesh) can be estimated.

Since this article is purely practical it may here be pointed out that for practical purposes there is a limit to which elaboration of an experiment needs to be pushed. It is possible to estimate beforehand how large a return must be given by a treatment to balance the cost. The experimental result must be at least as large as this, for there is no practical interest in a treatment which results in economic loss. An experiment will be satisfactory for its purpose if the standard error is small enough to establish results of the order of magnitude which is determined in this way by costs. In rubber this magnitude is often a good deal larger than for general field experiments on other crops. The cost of a continuous manuring programme for rubber might be put down for the sake of argument at about $15/- per acre per year then if the profit from the *extra* rubber produced as a result of manuring be placed at 15 cents per lb, an increment of 100 lbs. of rubber per acre must be looked for before manuring becomes economical. This would be a yield increase of some 25 or even 50 per cent. on a poor-yielding area. If the profit is placed at a lower figure this percentage increase must be still larger. Hence an experiment of great elaboration is not usually required. A probable error of 5 per cent or more would still allow the test to be classed as a "success" or "failure" in the economic sense.

The above remarks will have served their purpose if they establish in the mind of the reader the two points that a good experiment must provide (1) controls and (2) sufficient replication of plots for an estimate of error. The rest of the article may be devoted to a discussion of the details of experimentation which require attention for the attainment of accuracy.

Choice of an Area.

The first requirement in choosing a site is that it should fairly represent the whole area (of a particular age or condition) which it

is desired to benefit. As regards the trees themselves, areas which have not been stagnating too long give the greater promise of result. As regards the soil conditions it must first be ascertained that proper attention has been paid to matters like drainage and conservation measures. Very sandy soils are not so economical to manure as those having a fair proportion of clay to act as an absorbing complex.

The area covered by the plots should be as uniform as possible, in all respects—the lie of the land, age of trees, history of cultivation, height of the tapping cut, spacing of trees and so on. Lack of uniformity of tapping may render an area very unsuitable. It is not possible to correct yields for varying density in the stand of trees, so that areas which have become very variable by reason of disease are unsuitable for plot experiments.

Size of Plot.

Theoretically the size for the individual plot of rubber depends upon obtaining a large enough number of trees to form a total sample which shall not be unduly affected by the large variation between individual trees. The question has been investigated by several workers and the number of trees required variously assessed between 16 and 100. Although the smaller number might provide a large enough plot theoretically, it has the practical disadvantage of requiring special arrangements for recording. For practical reasons it is advocated that plots should be adjusted to the natural unit for estate recording; thus, for daily tapping, a plot may be half a task so that each cooly brings in two buckets representing the yield from two plots. For alternate daily tapping the same unit can be used; each cooly covers 4 plots altogether (2 each day), or the size of the unit may be enlarged to one task, in which case the cooly brings in the yield from one plot each day but alternates between two plots. On the whole the half-task plot gives the more compact experimental arrangement, but the whole-task plot may be chosen if it seems to give greater simplicity in recording, which ensures greater accuracy. The whole-task plot also avoids the risk that a cooly tapping two plots on the same day may mix or confuse the latex.

For other treatments which are distinguished from manuring by being applicable to individual trees, such as the application of substances for bark renewal, the lay-out of an experiment may be in rows of trees instead of plots. The results are then recorded for each tree. This gives more information than taking average values over a large number of trees, since it enables one to distinguish the variation of the results for trees of different types. For instance, some methods of stimulating latex yield might prove to be worth applying to trees which have run dry, although they might have disadvantages for trees in a more normal state.

Isolation of Plots.

The best method of isolating plots so that one treatment does not affect the trees on the contiguous plot is the use of 'guard rows' which are excluded from the experiment and isolated by a trench on each side. This may be viewed as a rather extravagant method since the 'guard' trees must either be rested or tapped separately. It is usually sufficient to isolate plots with a single trench between the border rows of trees. It is impossible to prevent edge effects entirely, but with a trench and plots of one acre or more, the edge effect is not large. The edge effect is reduced to a minimum by making plots approach a square in form as far as possible. Where the trench would run downhill it may even be advisable to dispense with it on grounds of the erosion produced.

Recording of Results.

The results may be recorded in various ways depending upon the estate organisation and the programme for the area concerned. Good results have often followed manuring when the rubber has been rested for a year or more after the application. In such a case records would be limited to bark thickness and girth, which could be taken at the beginning of the experiment and at yearly intervals afterwards. A suitable position on a panel to begin measurements of bark thickness is where the renewed bark is eighteen months to two years old. Test tapping over one or two months can be undertaken on areas which are otherwise being rested. As regards recording of yields, estates must suit their methods to their own organisation of labour. In the final returns it is sufficient to enter the monthly totals of rubber produced from each plot. A convenient method of arriving at the results is to dilute the latex from each tapping of each plot to a standard volume; an aliquot part of this is then taken for test coagulation and weighing while the remainder passes into the factory. Another method which has been found practicable is to manufacture separately the rubber from each tapping and to weigh the final factory product. Calculation from the amount of latex and the hydrometer reading is also a convenient method, but not the most accurate. If conducted in a careful manner by the same person each time the errors should smooth out, since a large number of readings go to the total for each entry of the results. Estate managers will easily utilise methods such as painting trees, buckets and tapping cups in distinctive colours, or the use of tapping cups of different kinds, in order to avoid mistakes between the field collection and the factory recording.

Tapping Errors.

The results of an experiment may be affected by differing skill of the tappers, or by some plots deriving benefit from earlier tapping than others, or again by cessation of tapping half-way through from weather conditions. These possibilities need to be clearly realised and dealt with. In a simple experiment with one treatment plus control, the error from tapping skill is covered if each tapper works on one plot of each kind. In more elaborate experiments where this is impossible, the band of tappers change their tasks at regular intervals according to a set rota. The point to be aimed at is so to distribute the error that, over the period of a year or so, all plots have an equal chance of good or bad tapping. The error from time of tapping can be looked after by seeing that the cooly begins at different ends of his task for alternate tappings. The lay-out may make such arrangements unnecessary. Effects of weather conditions can only be minimised by adopting a very cautious policy as regards tapping on a doubtful morning. If a "wash out" occurs, then treatment of trees should be equalised as far as possible but no record taken.

Covers.

For a strict experiment areas may be maintained clean-weeded. Since, however, clean-weeding is practically abandoned as an estate practice and it is of advantage that an estate experiment should be conducted under ordinary estate conditions, it is often advisable to permit the disturbing element of the presence of a cover. For a long range experiment it is possible to take the view that the manuring in the first stage can be mainly devoted to the encouragement of the cover. The usual course of events is that the rubber derives benefit later, and, by virtue of its increased leaf canopy, overshadows the cover and reduces it to minor and finally to insignificant proportions. From a more limited point of view, and particularly where a natural weed cover already exists, matters may be compromised by simple strip or patch weeding of the cover and then concentrating the application of fertiliser to these strips or patches. This takes advantage of the fact that the rubber has a far more extended root range than the cover plants, and gives the maximum of benefit to the rubber with a minimum of benefit to the cover.

Notes on Fertilisers.

By far the most general need of rubber is nitrogen. The soil becomes impoverished of its humus, the trees have a sparse leafage

and show dieback. The leaves are small and of an unnaturally light green colour. If the trees have not lost all vigour, nitrogen will effect great improvement in foliage. When there is a good leaf canopy (as is usual on flat peaty areas) nitrogen is not required.

Signs of potash starvation are usually accompanied by stunted growth rather than die-back. Nitrogen is usually adequate in a virgin soil, but fails later on, so that die-back appears as a response of the tree in adapting itself to reduced supplies. With potash and phosphate, on the other hand, the deficiency is present from the start and growth is slow, with die-back less noticeable. The specific signs of potash starvation are a premature yellowing of the leaf, beginning at the edges. This may be specially looked for in a cover, if one has been tried. Sometimes the soil will still contain humus and nitrogen, so that dark green leaves and yellowing ones will form a striking contrast on trees much below their normal size. Potash deficiency is often marked on the more sandy soils.

Phosphates appear to be much more effective for young rubber than for old. They should form the main ingredient for leguminous covers.

When a fertiliser is soluble it can be applied by simple broadcasting, taking care not to choose a day when the soil is saturated and wet. Other fertilisers should be applied by envelope forking.

The trees have the greatest need for food during the flush of new leaf growth after wintering. Since most nitrogenous fertilisers reach their maximum effect only after some weeks from application, the best time for application is just before the first appearance of wintering. If this is missed, the dry season of July-August is the next best to fall back upon.

The following list gives suggestions for the amounts of fertiliser to use at each application. The statement in hundred-weights per acre is easily reduced to amount per tree, from the known stand of trees. For young rubber the calculation may be made on the basis of the feeding area of the tree. It is not difficult to estimate the root spread from the size of the tree, and to calculate on the basis that 1 oz. per square yard is about 3 cwt. per acre. The amounts are based on general practice in the absence of better information. It may be remarked that other tree crops (for example citrus fruit trees) have been found to require very much heavier applications for the best economic return, but it would not be safe to argue from analogy. It is safe to say, however, that success is very likely to be missed by a too frugal approach. It is therefore recommended that an experiment should be begun with a full intention to give say, three yearly applications before applying the results for guidance as to the further programme.

Amount of Fertiliser per Acre.

Nitrogen.

Urea	Soluble	2 — 3	cwt.
Sulphate of Ammonia	Soluble	$3\frac{1}{2}$—$4\frac{1}{2}$	cwt.
Calcium Cyanamide		4 — 6	cwt.

Potash.

Sulphate of Potash Muriate of Potash	Soluble	2 — 3	cwt.	
Kainit	Soluble	5 — 8	cwt.	(according to grade)

Phosphate.

Basic Slag		2 — 4	cwt.	(according to grade)
Superphosphate	Ordinary grade	2 — 4	cwt.	
	Concentrated	1 — 2	cwt.	
Ground Rock Phosphate		2 — 4	cwt.	
Perlis Guano		2 — 8	cwt.	(according to grade)
Sulphurophos		3 — 7	cwt.	

Nitrogen and Phosphate.

Leunaphos	Soluble	3 — 5	cwt.
Ammophos	Soluble	3 — 5	cwt.

Complete Fertilisers.

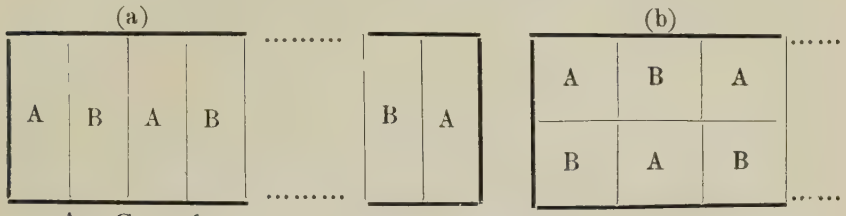
Nitrophoska	Soluble	4 — 6	cwt.
Cresite (contains lime)		4 — 6	cwt.

It is usually required by law that vendors of fertilisers shall supply therewith a statement of an analysis showing the content of nitrogen, potash or phosphoric acid as the case may be. Purchasers need this protection particularly in the case of compound fertilisers containing organic constituents. The analysis figures can be used as a basis for a rough comparison of value between various fertilisers offered. The price of basic slag, for example, divided by the percentage of phosphoric acid will give the price paid for one "unit" of phosphoric acid. Such comparisons must be weighed in conjunction with the special advantages offered by each variety. For many purposes, for example, basic slag may derive additional value by

reason of its lime content, when being compared with another source of phosphoric acid such as superphosphate.

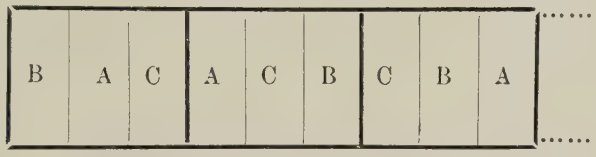
Simple Schemes Suggested for Plot Lay-out.

Lay-out I. One treatment, alternating with control.



A. Control.
B. Manured. Nitrogen only or a complete fertiliser.
Unit, one or one-half tapping task, as convenient.
At least five replications: ten are better.

Lay-out II. Two treatments and control.



Treatments laid down in blocks of three.
Within each block of three the treatments appear in random order. Block repeated five or more times.
A. Control.
B. Nitrogen only.
C. Nitrogen plus one or both minerals, or nitrogen only in a larger application than B.

Lay-out III. Three treatments and control.
Gives a block of four plots. These are arranged in random order in each block. The blocks may be arranged together in any way convenient.
A. Control.
B. Nitrogen only.
C. Nitrogen plus potash.
D. Nitrogen plus phosphate (or a complete manure).

Lay-out IV. Latin square. This lay-out has many advantages for more elaborate experiments. The plots form a latin square arranged so that each row of plots (considered in either direction) contains one plot of each treatment (including a control). With that restriction the arrangement is otherwise at random. Block 6 at the Rubber Research Institute Experiment Station is an example of this arrangement and may be found described in this Journal (Vol. I. No. 4. p. 241).

A RECENT OUTBREAK OF SECONDARY LEAF-FALL DUE TO OIDIUM HEVEAE.

BY

F. Beeley.

During the re-foliation period, after the heavy wintering of rubber trees this year in Malaya a large number of enquiries was received at the Institute from estates in connection with a secondary leaf-fall.

All specimens of leaves and flowers received for examination showed that the material was infected with Mildew disease caused by the fungus *Oidium Heveae.*

On account of the severe character of the outbreak of the disease in two districts, I was requested by the Director to visit estates and small holdings in these districts and to report on the situation.

The following is a report of the results of the observations made during the tour.

While travelling from one place to another a keen watch was kept for any signs of the disease in small holdings and kampongs by the roadside. As a result of this it can be stated that a heavy infection of *Oidium Heveae* in all areas lying on the route taken was observed. In many cases the presence of the fungus was demonstrated microscopically. This was best done on leaves and flowers picked fresh from the tree. Following recent rains considerable difficulty was experienced in demonstrating the active sporulating fungus on the leaves, but on no occasion was difficulty encountered in demonstrating a vigorous sporulating growth of the fungus on the flowers and flower stalks. It is presumed that the natural hirsute condition of the flowers affords a means of protection from the elements, and incidentally a means of carrying over infection from one set of new leaves to the next despite occasional heavy showers of rain in the meantime.

The following facts were noted:—

1. Very few inflorescences remained on the tree.
2. Very few flowers were observed to open to maturity.
3. Early wintering trees had, almost without exception, failed to set fruit.
4. Late wintering trees though bearing a heavy flush of flowers were all so heavily infected with the fungus that few if any flowers would reach maturity.
5. The mildew fungus usually attacks only young leaves of say from $\frac{1}{2}$ to 2 inches long. Investigators in Ceylon and the Netherlands East Indies, however, report that older leaves may also be attacked.

6. Leaves may apparently recover from an attack, but remain for a long time in a weak pendant condition, eventually extending to give malformed, wrinkled, pale or mottled leaves, many of which are so weak as to be forced off by subsequent wind or rain.

7. It has been frequently observed that in advanced cases, when the leaf is beginning to discolour, great difficulty may be encountered in demonstrating the presence of the Oidium fungus, while other secondary fungi may often be found on such specimens. It seems reasonable to conclude that the fungus ceases its activity on the leaves as soon as the leaf begins to die, or as soon as the leaf has become old enough to have acquired a cuticle which, so far as this fungus is concerned, may be regarded as impenetrable.

8. Advanced cases in which the disease resembles "white wash" spots on the leaves as are sometimes found in the Netherlands East Indies and Ceylon were not found on the trees in the districts visited. Similar specimens found on the ground when examined microscopically showed the white wash effect to be due to other fungi commonly found on decaying vegetable matter. The writer has successfully photographed an extraordinary dense growth of the Oidium fungus on the leaf vein, where the conidiophores and conidia were so dense as to be in contact with each other and bearing one to three spores in chainlike formation, and yet the growth was visible to the naked eye only when observed in certain angles of light, when a slight glistening furry surface could be distinguished from an otherwise smooth leaf surface. On the flower stalks a glistening powdery appearance characterises the presence of the mildew. (See Plate, page 65).

9. The extent of actual leaf fall seemed to be in proportion to the density of foliage normally produced by the trees. Trees in good soil bearing a heavy foliage suffered a heavier fall of leaf than trees in poorer soil bearing a lighter foliage. A far more rapid recovery had however taken place in the heavier foliaged areas. The flowers in all cases were almost completely destroyed.

10. The mildew was demonstrated microscopically on leaves of trees of all ages over 2½ years. Several plants of younger age in new clearings were observed to be suffering from attack by mites and leaf spot fungi, but this may be due to the drought and not to an after-effect of an attack by *Oidium Heveae*. Partial wintering of young trees of 2—4 years old made the attack in such clearings appear only in a few branches the leaves on which were sufficiently immature to be susceptible.

11. Cultivation or schemes for soil conservation had, where adopted, produced a more rapid recovery from the disease. This can be shown by the quicker rate at which leaves in such areas had assumed the semi-rigid extended position, while on uncultivated areas and on poor soils the leaflets, though of normal size for their age, remain hanging vertically.

12. A few trees were observed to have their second flush of young leaves heavily infected with the fungus. Such foliage was light, weak and pale yellow green in colour.

13. No special type of tree appeared to be affected to a greater extent than any other type. The taller trees appeared to suffer more than those of normal height within the same area. Closely planted small holdings' rubber appeared to have shed more leaves than more widely planted estate rubber, as evidenced by the amount of green leaf on the ground. This quantity of green leaf on the ground may however be due to the more humid atmosphere within the more densely planted areas and hence a slower death and decomposition of the young fallen leaves.

14. Soil types, cover crops and period of resting from tapping did not appear to have any influence on the incidence or severity of the disease.

15. Manuring also did not seem at first sight to have any great effect on the severity of attack. Dr. Haines, Head of the Soils Division, informed me of the various estates in the districts visited which were carrying out manurial experiments, and special attention was paid to these. In a few cases wintering had been delayed sufficiently by the nitrogenous manure applied to make the arrival of the young leaves coincide with the arrival of wet weather, and consequently these had escaped the disease to some extent. The flowers in such areas were almost completely destroyed despite the rains. Other manured areas owing to their geographical position had not had rain so early, and had suffered as badly as other non-manured areas. It would seem therefore that an increase in vigour of a tree by natural or artificial means does not render the small leaves immune to attack by the mildew fungus.

16. No immune trees were observed, always one could observe some branch of the tree which, wintering later than the others, could still be seen to be suffering from the disease.

17. The normal wintering period for the district is one month from the first week of February to the first week in March. Owing to the recent mildew attack many trees in the district are only just getting over the wintering period in April, due to the destruction of the earlier leaves formed previous to the advent of wet weather in later March. Since the rain however, the trees are assuming a foliage which is perhaps less dense than in normal years, and which will in all probability fall off at an early date and be replaced by other foliage about the months of July—September as is often experienced in dry districts.

18. Areas of known infection consist of practically the whole of Selangor, Negri Sembilan, Malacca and North Johore.

Flower infection is complete in all districts, but the leaf infection is most serious in Malacca and southern Negri Sembilan and decreases

with the increase in distance from these areas. Though leaf infection has been demonstrated many times in Selangor, very little if any leaf fall has actually occurred; its effect, however, can be seen, as in the unfallen leaves of trees in Malacca, in the form of malformed, twisted, mottled, pale green leaves.

19. The association of mites with Oidium Leaf Fall was not borne out by my investigation. Mites were present only in advanced stages of the disease, when the mildew fungus was difficult to find and when decomposition had set in. Apparently healthy young green leaves and flowers were observed to be heavily infected with the fungus, while mites were not present.

20. Owing to the very widespread infection, the method of spread could not be determined. In all probability infection is caused by wind borne spores. No clue as to the type and location of a resting spore was found. Experiments are however being carried out in the laboratory with a view to determining the method of formation, type and viability of the resting spore of the causal fungus. The difficulty of the investigation is increased by the fact that as yet no means have been discovered for the artificial culture of the fungus.

21. The amount of rainfall seems to have an all-important influence on the severity of attack, especially on the leaves. The following table will show the differences in rainfall for the first quarter of the years 1929 and 1930. In 1929 very few cases of mildew were recorded. In 1928 a low rainfall and correspondingly numerous cases of mildew were recorded. In the table below, the Asahan district is recorded as having a greater fall of leaf than neighbouring districts despite its higher rainfall. This is probably due to poor rubber and poor soils and hence a slower and poorer recovery from wintering and disease.

District	Rainfall 1929 Jan-March. (inches)	Rainfall 1930 Jan-March. (inches)	Flower infection	Leaf Infection	Extent of Leaf fall
K. Lumpur	18.5	20.0	Very heavy	Slight	Very slight
N. Sembilan	21.25	6.1	do	Heavy	Moderate
Tampin	23.5	6.2	do	do	do
Jasin	15.84	8.84	do	do	do
Asahan	16.77	9.02	do	do	Considerable
Tangkah	21.01	8.07	do	do	Moderate.

22. The possible effect of the disease upon the yield of rubber per acre was an important part of the investigation. The results of this part of the work are, however, inconclusive.

The removal of restriction in November, 1928, change of system of tapping, change over from lower to high panel, introduction of soil conservation schemes, lowering of number of trees per tapping task, change over from Chinese to Tamil tappers or vice-versa, the unusual drought and introduction of periodic resting of trees from tapping, are all factors which affect the yield per acre and were encountered to a greater or less extent on the estates visited. It was therefore deemed advisable not to attach any importance to the figures obtained many of which are extremely contradictory. It seems reasonable to suppose however that the Mildew Disease of rubber trees will prolong the lowering of yield effect of normal wintering for at least one month. This fact is borne out on estates where soil conservation work had not been carried out in recent years, by a comparison of yields for 1930 with those of similar months in previous years. Here again the abnormal drought may be the chief factor concerned. If an appreciable loss in yield of say 25 lbs. or over per acre can be shown as a direct result of the mildew attack, then in subsequent years, when the two months previous to wintering are abnormally dry, treatment by means of sulphur dust should be of commercial value.

Meantime it must be realised that experience so far shows that climatic conditions in Malaya are unsuited to a prolonged activity of the fungus and therefore extensive losses due to a mildew attack are not to be expected.

The rains recently experienced in the districts visited had almost completely checked the activities of the fungus and rapid recovery of diseased leaves was taking place.

The chief effect of mildew attack will be felt in the seed harvest. In the brief time at my disposal I was unable to record having seen a single young seed, while extremely few flowers were observed to have developed beyond the bud stage. All floral specimens examined showed a heavy infection of the fungus. Lack of seed for future planting programmes is therefore more likely to cause anxiety than a possible appreciable reduction in yield.

DESCRIPTION OF PLATE.

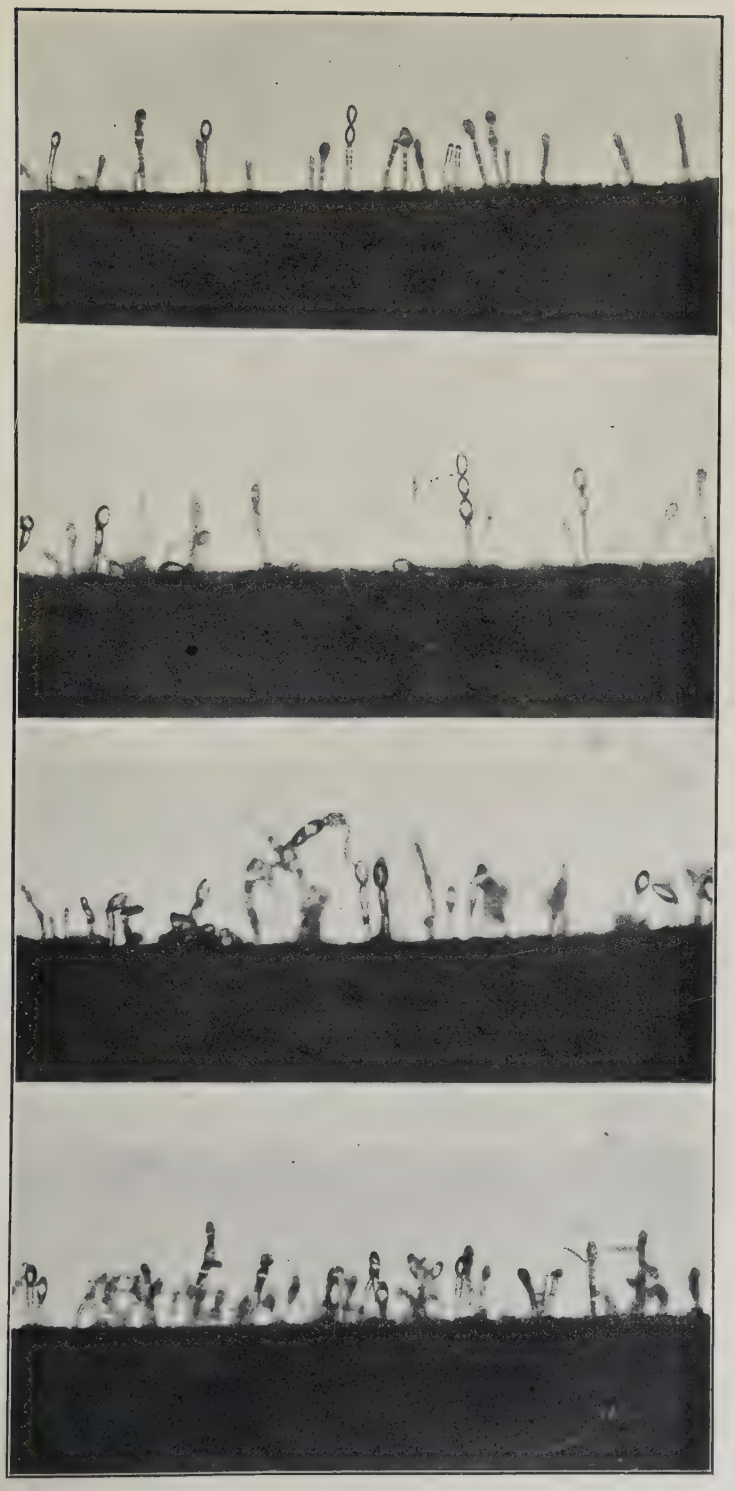
The fungus *Oidium Heveae* photographed in its natural state on the midrib of a very young leaf of Hevea Brasiliensis. x 114.

Note. (1) Chains of spores at the end of the upright, unbranched conidiophores.

(2) Spores germinating in situ on the conidiophore.

(3) Density of growth which to the naked eye appeared merely as a silken sheen on the midrib regions of the underside of the leaf.

Photo by H. Sutcliffe and F. Beeley.



Oidium Heveae.

COST OF SULPHUR DUSTING

FOR

OIDIUM LEAF DISEASE.

Since abnormal leaf fall of rubber trees caused by the mildew fungus—*Oidium Heveae*—has not become an epidemic disease in Malaya, as in Ceylon and Java, no systematic spraying or dusting has yet been carried out, so that the cost of treatment in Malaya is not known.

It is thought that the following results of sulphur dusting—the most successful remedial treatment known at present—in Ceylon and Java will be of interest and should be placed on record for the information of the planting community.

At present, apart from certain experiments on dusting sulphur from aeroplanes in Java, the only dusting machine used has been the Bjorklund Motor Duster, a machine designed and sold in Java. (Note:—One of these machines has been purchased by this Institute for experimental purposes).

JAVA.

According to the pamphlet issued by the makers of the Bjorklund Duster, the costs in Java are as follows on the basis of 150 acres per 8 hours' working day. It is considered that the treatment of a larger acreage can be effected under favourable conditions. The figures are based on the dusting of large areas.

4 Coolies to carry Duster,	...	f. 2.00
1 Coolie to feed sulphur,	...	0.50
8 Coolies to carry sulphur,	...	4.00
1 Mandor,	...	0.85
Petrol and Oil mixture ($2\frac{1}{2}$ litres per hour at 32 cents per litre) per 8 hours,	...	6.40
Overhauling, spares etc.	...	1.00
Sulphur powder (5 kgs. per acre at $11\frac{1}{2}$ cts.)	...	86.25
		f. 101.00

This is equivalent to 67.3 guilder cents per acre, but does not include cost of European supervision.

On the assumption that six dustings may be required during the season, the cost on the above basis would be 4.04 guilders per acre.

On one estate in Java an area of 2,580 acres was treated at a cost of 2.68 guilders per acre. It is considered that 4 to 7 dustings may be required at 10 day intervals for the first three rounds and at 15—20 day intervals for subsequent rounds.

CEYLON.

Experiments have been carried out recently by the Mycologist (R. K. S. Murray) of the Rubber Research Scheme (Ceylon) and the results are published in Leaflet No. 11 dated the 25th April, 1930.

Although the experimental work has not yet resulted in complete control of the disease, it promises to be an effective and economical means of control.

The sulphur used was Kawah Poetih volcanic sulphur from Java of which the higher grade known as "Flotate" sulphur was employed. This product contains 90—95 per cent of sulphur and a maximum moisture content of 5 per cent. This sulphur must be dried in the sun before using.

The cost of the sulphur is about 6 rupee cents per lb. in Ceylon.

The figures for cost of sulphur dusting in Ceylon on the basis of 100 acres per day are as follows:—

1,200 lbs. of sulphur (at 6 cents per lb.)	...	Rs. 72.00
4 Coolies to carry duster	...	2.40
6 Coolies to carry and feed sulphur	...	3.60
1½ gallons of petrol oil mixture	...	3.00
Total	...	Rs. 81.00

This is equivalent to 81 rupee cents per acre or 4.86 rupees per acre for six dustings.

REMARKS:—

The cost of labour in Malaya may be estimated as similar to the Java figures in dollar cents.

The cost of "Flotate" sulphur F.O.B. Batavia is 102.50 guilders per 1000 kilogrammes i.e., approximately 1 ton, for quantities of not less than 10 tons. For quantities of less than 10 tons the price is increased by 5 per cent.

It is considered that a moderate estimate of the cost for sulphur spraying in Malaya would probably be about 4 dollars per acre for the season.

SECONDARY LEAF FALL CAUSED BY OIDIUM HEVEAE.

A Notifiable Disease.

The attention of all rubber planters is drawn to the following Notifications relating to secondary leaf fall caused by the Mildew fungus—*Oidium Heveae.*

(1) Notification No. 859, Ordinance No. 166 (Agricultural Pests), published in the Straits Settlements Government Gazette Vol. LXV. No. 271—May 2nd, 1930, which reads as follows:—

In exercise of the powers vested in him by Section 18 of Ordinance No. 166 (Agricultural Pests) the Governor hereby amends the "Pests Notification Rules 1925" which were published as Notification No. 769 in the Gazette of the 1st May, 1925, by adding to Clause 1 of the Schedule a new paragraph (d) as follows:—

"(d) Secondary leaf fall caused by *Oidium Heveae,* Steinm, a disease of the leaves.	Within fourteen days of first finding pest."

(2) Notification No. 3129 under the Agricultural Pests Enactment, Federated Malay States, 1926, published in the Federated Malay States Government Gazette Vol. XXII, No. 11 of 9th May, 1930, which reads as follows:—

In exercise of the powers vested in him by Section 19 of the Agricultural Pests Enactment 1926, the Chief Secretary to Government hereby amends the Pests Notification Rule 1927 which was published as Notification No. 885 in the Supplement to the Gazette of the 11th February, 1927, by the addition to the Schedule of the following:—

Name of Pest.	Period within which Notice to be given.
(1) Pests of Rubber.	
(d) Secondary leaf fall caused by *Oidium Heveae*, Steinm, a disease of the leaves.	Within fourteen days of first finding pest.

In accordance with these rules the presence of this disease must be reported to the Director of Agriculture, S.S. & F.M.S., Kuala Lumpur or to the Agricultural Field Officer in the area in which the discovery is made, within the period specified.

Specimens of suspected material should be forwarded to the Director of the Rubber Research Institute for a correct diagnosis, by planters who are not acquainted with the features of the disease.

B.J.E.

RESULTS OF A QUESTIONNAIRE ON SMOKE-CURING OF RUBBER.

BY

R. G. Fullerton.

Towards the end of last year a questionnaire was circulated among some fifty estates in various parts of the country with the object of collecting information on the smoke-curing of sheet rubber. The drying of sheet rubber in smokehouses according to present practice involves the use of a simple type of plant and to some extent the methods employed are crude. The process is analogous to that used for the curing of fish, in so far as smoking and drying are effected by the slow combustion of wood fuel in a simply designed building, the object being to dry and at the same time to preserve the product in good condition. But this analogy must not be carried too far, since in the case of rubber the conditions during drying must as nearly as possible be such as to give a product which conforms to more definite and rigid standards of quality. In the first place there is the standard imposed by the market, which is based largely on cleanliness and general appearance and secondly there is that demanded by manufacturers, which is based principally on the physical quality of both the raw and vulcanised rubber. Considering, therefore, present methods of smoke-drying rubber in relation to the high standards of quality demanded of the product, it may be said that the process is somewhat crude, since it is not of such a nature that conditions during drying can be controlled with a great degree of exactitude. If, for example, the heating unit at present employed were replaced by a system of steam-heated pipes, the temperature inside the building could be maintained between the required limits with greater ease, and the risk of contamination of the product with dirt would be greatly lessened. Of course, in such a case probably additional antiseptic treatment would have to be given to the sheets to prevent the growth of fungi, and questions of economy have still to be considered.

This enquiry was conducted in order to obtain comparative figures for the efficiency of various types of smokehouses and for fuel consumption. As regards the latter point, it is well known that most estates obtain wood fuel for smoke-curing from rubber trees felled according to "thinning out" programmes, and few are so fortunately situated as to be able to obtain adequate supplies of jungle timber at reasonable cost. It is not claimed that the data here given for fuel consumption are representative of the whole of Malaya, but it is hoped that they will provide the practical planter and busi-

ness man with a useful figure to incorporate in an estimation as to future fuel supplies.

It is hardly necessary to point out that there are many difficulties to be encountered in drawing conclusions from statistical data collected on such a subject as smoke-curing, since not only are there a very large number of factors affecting the variation of each group of measurements, but also in some cases the factors cannot be measured quantitatively. The results are set forth in Tables I A and I B and an explanation of the scheme of tabulation follows.

Scheme of Tabulation. Table I A.

Column (1) *Estate Number.*—Each estate is referred to numerically, and where there is more than one smokehouse on the estate, the numerical headings are sub-divided by suffixing letters of the alphabet e.g. 11A, 11B.

Column (2) *Design of House.*—In referring to the smokehouse according to design of the building a division into different groups has been made. The houses in two of the groups conform to standard types, viz. "Devon" (1) and "Third Mile" (1), but in the case of all the others the design varies so considerably that it is possible to refer to them only according to the number of storeys in the building.

Column (3) *Design of Fire-Chamber.* In referring to the fires, the use of the word *furnace* has been purposely avoided. The use of this term is to be deprecated in that it suggests intense heat, whereas the ideal to aim at with smokehouse fires is the slowest combustion of the fuel which is consistent with the maintenance of the temperature between the desired limits. Instead the word *fire-chamber* or fire box is used.

In a few cases the fires are not enclosed, but are placed on open hearths on the ground floor of the building. Apart from these, the fire-chambers have been classified firstly by making a distinction between those in which the stoking operations are conducted inside the building and those which provide for stoking outside the house. These classes are then sub-divided as follows:—

Inside Stoking	Pit firing.	*Outside Stoking*	Trolley fire-boxes.
	Fixed iron fireboxes		Brickwork chambers.
	Brickwork chambers.		"Third Mile" Type.
			External chamber with flue distributors.

Pit firing covers those cases where the fuel is burnt in brick-lined pits sunk in the ground, the pits being covered with a perforated iron plate.

Fixed iron fire-boxes refer to chambers of the cylindrical drum type placed in contact with the ground floor, while in trolley fire-boxes the drum is mounted on a truck so that it may be wheeled outside the house for stoking and cleaning. In a few cases the fire-box is rectangular in section and has a hinged door opening on one of the sides to facilitate stoking. In all cases openings at the base of the box—if any—are small in size, so that there is little ventilation through the fire from the bottom upwards.

Brickwork chambers are usually rectangular in section and vary considerably in design. As a rule they are more elaborate than the iron fire-boxes just described and a hinged door opens on one of the sides to allow of stoking. The top may be covered with a lid of perforated sheet iron, while in other cases various forms of chimney distributors are provided as outlets at the top. For outside stoking a covered way is usually provided leading to the outer wall of the building when the fire-chamber itself projects some distance into the interior.

The "Third Mile" or fixed horizontal drum type is well known and requires little comment. Stoking operations are conducted outside the building and a flap ventilator, controlled from the outside is provided for adjusting the aperture of the chimney exit.

In one case the fire-chamber itself is situated just outside the building and the hot gases and smoke from the fire are led underground through a system of flues to the interior.

Column (4) *House Ventilation.*—This refers only to vents at the top of the building. Mention is not made of ventilation at the foot of the house, since it is difficult to refer to it briefly in tabular form. The construction of a smokehouse is not such as to render it air-tight. For example in the "Third Mile" type a slow current of air passes through the fire-chamber, and in the general case air vents are unintentionally provided by chinks in the walls and round the edges of the doors leading to the ground floor. Reference will be made later to the advantages to be gained by providing special air-inlets at the base of the walls as a precautionary measure.

Provisions for ventilation at the top are referred to under the following heads:—

1. Space between eaves of roof and walls.
2. Jack-roof.
3. Chimney Ventilators.

Column (5) *Fire-Box Ventilation.*—In iron fire-boxes, whether fixed on the floor or mounted on trolleys, there are generally no openings designedly made in the sides and bottom, although the box may not fit very closely on the ground or on the floor of the trolley carriage. The top is, however, open to the air and these conditions are referred to briefly in the table as "Open." The same applies to combustion of the fuel in pits sunk in the ground.

In other cases a current of air passes *through* the fire by means of openings in the stoking door, in some cases special adjustable air vents being provided as in the "Third Mile" type of fire-chamber. A few iron fire-boxes also come under this heading.

Column (9) *Limits of Temperature.*—This refers to the temperature maintained inside the drying rooms in which the sheets are hung.

Table I B.

Column (3) *Average Curing Period in Days.*—This gives [illegible] number of days which elapses between

ERRATA.

(1) In the article on "Results of a Questionnaire on Smoke-curing of Rubber," Quarterly Journal Vol. 2, No. 2 page 72 substitute "1.6 x 30/10=4.8" for "1.6 x 30/3=4.8".

chambers in cubic feet, the space above the walls bounded by the roof not being included. Thus the greater the space left between the racks, for example such as is occupied by gangways, the lower the figure for capacity, other things being equal.

Column (5) *Monthly Output.*—The figures here given are a measure of the comparative efficiency of the various designs of smokehouses irrespective of the type of fire-chamber employed, since, as will be seen from Table I A column (9), the limits of the temperature of drying are practically the same in each case. They give the monthly output of dry rubber in lbs. per cubic foot of drying space, and are obtained by multiplying each figure in Table I B column (4) by the corresponding number of complete charges of sheet which can be cured per month. The number of charges is obtained by taking the number of days in a month as 30 and dividing this by the corresponding figure in column (3) for the period of curing in days. For example in the case of Estate No. 9, the figure for monthly output or efficiency is:—

$$1.6 \times {}^{30}/_{3} = 4.8$$

Although not all the smokehouses are working to full capacity these figures represent the maximum output obtainable in each case and so they are fairly comparable among themselves.

Column (6) *Fuel Consumption.*—Each estate was asked to weigh the wood fuel consumed in the smokehouse over a period

of one month, and the figure for fuel consumption is obtained by dividing the weight of fuel in lbs. by the total weight of dry rubber in lbs. smoke-cured during the same month. In other words, fuel consumption is expressed as lbs. of wood consumed per lb. of dry rubber.

Column (7) *Thickness of sheet.*—Each estate was requested to send a representative sample of the product. The average thickness of the sheets was then obtained by cutting a piece of the same surface area from each (about 40 square cms.) and obtaining the weight of each piece in grammes. From these data and the known specific gravity of rubber, the average thickness of each sheet was calculated in millimetres.

Column (8) *Depth of colour of cured sheet*—The representative samples of smoked sheet sent to us by the various estates were compared roughly as to depth of colour, the terms light, medium, and dark being used in this connection. This comparison, however was not intentionally related to the grading of the market as to depth of colour and is purely arbitrary.

Column (9) *Complaints re Mouldiness.*—The estates were asked to state whether or not complaints had recently been made by buyers as to mouldiness of consignments of smoked sheet.

Comparison of the Efficiency of the Smokehouses.

As has been pointed out, the figures given in Table I B column (5) for efficiency are fairly comparable among themselves, since they represent the maximum output obtainable. Moreover, efficiency as here defined refers to the design of the smokehouse building and is independent of the design of the fire-chamber employed, the temperature of drying being almost the same in each case. It takes no account of fuel consumption. Hence what we are about to compare is the efficiency of the various designs of building.

For this purpose the various designs have been divided into three groups—"Devon" type, "Third Mile" type, and Miscellaneous. The houses in the first two groups conform to a standard type as regards design although, as will be seen from Table I A the design of the fire-chamber varies somewhat. In the majority of cases, however, the designs of the houses are so miscellaneous that it is possible only to class them as such.

In Table II, the figures given in Table I B for monthly output in lbs. of dry rubber per cubic foot of drying space, are set forth under each group heading, and at the foot of each column the results of the analysis are given, the symbols having the usual statistical significance.

It will be seen that there are 12 "Devon" smokehouses, 17 of the "Third Mile" type, and 32 of miscellaneous design. Hence in making

a comparison of efficiency due weight must be given to the fact that there are not the same number of observations for each group.

TABLE II.

MONTHLY OUTPUT IN POUNDS OF DRY RUBBER PER CUBIC FOOT OF DRYING SPACE.

"Devon" Type	"Third Mile" Type	Miscellaneous Type
8.6	2.4	3.9
11.0	2.2	2.3
4.3	6.0	2.3
6.3	3.8	3.0
7.3	4.9	2.4
5.1	4.2	2.7
6.0	5.5	4.8
6.9	2.3	2.6
6.0	4.3	1.6
6.0	2.4	1.9
5.4	3.8	3.8
6.4	3.6	3.7
	5.2	3.8
	4.5	2.3
	3.3	2.0
	3.3	2.0
	3.3	2.4
		2.2
		3.7
		5.1
		1.8
		2.1
		4.2
		2.7
		3.5
		4.8
		2.7
		2.7
		2.7
		4.1
		2.5
		2.0
N = 12. Mean = 6.7	N = 17 Mean = 3.8	N = 32. Mean = 2.9
S.D. = $\sqrt{\frac{\Sigma D2}{N}}$ = 1.7	S.D. = $\sqrt{\frac{\Sigma D2}{N}}$ = 1.1	S.D. = $\sqrt{\frac{\Sigma D2}{N}}$ = 0.9
C. of V. = $\frac{100 \times S.D}{Mean}$ = 25.4	C. of V. = $\frac{100 \times S.D.}{Mean}$ = 28.9	C. of V. = $\frac{100 \times S.D.}{Mean}$ = 31.0
p.e. = 2/3 S.D. = 1.1	p. e. = 2/3 S.D. = 0.7	p.e. = 2/3 S.D. = 0.6

A comparison of the coefficients of variation (C of V) for the three groups shows that the figures vary most with those of miscellaneous design and least with the "Devon" type, those for the houses of "Third Mile" design being intermediate in this respect. There is however not much difference between the coefficients themselves and hence the mean values for each type are fairly comparable. The figures for probable error (p.e.) give the following results:—

1. The value for the "Devon" type lies between (6.7 ± 1.1) i.e. between 7.8 and 5.6.
2. The value for the "Third Mile" type lies between (3.8 ± 0.7) i.e. between 4.5 and 3.1.
3. The value for houses of miscellaneous design lies between (2.9 ± 0.6) i.e. between 3.5 and 2.3.

The results therefore show that, of all the smokehouses examined, efficiency, as here defined, is significantly greatest for those of the "Devon" type.

It must be pointed out that among those houses classed as miscellaneous are a few giving higher figures for efficiency than the mean value of the "Third Mile" type, although none are higher than the mean value for the "Devon" type. This means that "Devon" houses take precedence over all the others examined, but one is not justified in saying that those of "Third Mile" design are second in order of merit, for the classification of the others under one head does not imply that they all conform to a standard design, but that so few are of the same type that it is not possible further to sub-divide into groups of the same class. For example it will be seen from Table II that in one case classed as miscellaneous a figure of 5.1 was obtained, and had there been a sufficient number of others of the same design as this, the mean figure for the class might have compared favourably with that for the "Third Mile". One can say, however, that the efficiency of the "Third Mile" design of building as shown by this enquiry is fairly satisfactory although considerably lower than the "Devon".

The higher output of "Devon" smokehouses depends on several factors. In the first place smoke-curing is here a continuous process since the fires are not closed down during the time that freshly machined sheets are being hung in the smokehouse and the dry rubber removed. Any rack may easily be wheeled to the outside verandah for inspection, and for emptying and filling operations, without disturbing the continuity of smoke-curing in the rest of the building, whereas in all other cases the fires must be "damped" or extinguished in order that the coolies may enter the building. The total period of curing for the Devon house is therefore less. Again practically the whole of the drying space is occupied by racks carrying the rubber, and hence a greater weight of rubber is packed per unit of drying space than in other cases. Furthermore the dimensions

of the building are such that efficient ventilation is easily attained, for the building is tall, the height being somewhat greater than the length or breadth, no account of course being taken in this consideration of the dimensions of the verandahs, which are external to the house.

Relation between Efficiency and Thickness of Sheet.

From a comparison of the figures given in Table I B columns Nos. 5 and 7 for monthly output in lbs. of dry rubber per cubic foot of drying space and thickness of sheet respectively, one finds a correlation coefficient of 0.1 taking all those estates for which both figures have been determined. This figure is very low and shows that within the limits observed the average thickness of the sheet has no appreciable effect on the efficiency. The average thickness of the sheets examined is 3.0 mm. If however the sheets are much thicker than this in places—for example at the edges—the period of drying is increased.

Fuel Consumption.

It will be seen from Table I B that the figures for fuel consumption vary very considerably, the average being 1.6 lbs. of fuel per 1 lb. of dry rubber. From the data collected, it is not possible to grade the various types of fire-chambers according to their economy in fuel consumption as has been done in the case of design of the smokehouses themselves, since as has been pointed out, in the latter case the figures for efficiency are independent of the type of heating plant employed, since the temperature of drying is almost constant. In the case of fire-chambers, however, the rate of fuel consumption is dependent not only on the ventilation of the fuel container but also on the ventilation of the building as a whole. Again all the smokehouses are not working at their maximum capacity and it is not possible to make an allowance for this so that a fair comparison may be made. In order to obtain fairly comparable results, one would have to test various types of fire-chambers in the same smokehouse working as nearly as possible under the same conditions, and of course no great advantage would accrue from such an experiment, since it is obvious that all that is required of the heating unit is that it shall work with the slowest combustion of the fuel which is consistent with the maintenance of the desired temperature of drying. Slow combustion of the fuel involves the production of more smoke than when combustion is rapid. From this point of view, therefore, one type of fire-chamber is as good as another provided the ventilation is adjusted so as to give the optimum conditions, and this

is a matter which must be decided by the experience of the operator for the individual smokehouse.

The variation in the figures for fuel consumption is to some extent due to variation in the capacity of the drying chambers expressed as lbs. of dry rubber per cubic foot of drying space—in other words the closeness of the packing of the sheets in the building. As pointed out it is also due to the fact that not all the smokehouses are working to full capacity. The efficiency of the smoke house is also affected by the stoking and the capacity of the fire box.

Period of Curing.

From the data set forth in Table I B one finds that the average period of smoke-curing is 10½ days. Here again there is considerable variation in the figures and again a large number of factors are responsible. Within the limits of thickness observed there is no relation between thickness of the sheet and rate of curing nor are variations in the depth of colour of the product responsible to any considerable extent except in one case (Estate No. 47) where the curing period is 20 days. In this case, it was ascertained that the long period of curing was necessitated by the fact that the sheets were very thick at the edges owing to faults in manufacture. The finished product was therefore very dark in colour.

Among the more important factors responsible for the variation may be mentioned the following:—

(a) Ventilation depending on the design of the building.
(b) Temperature of drying—although in the present investigation the limits of temperature reported are practically the same in each case.
(c) Time occupied daily in filling the house with the fresh crop and removing dry rubber.
(d) Closeness of packing of the sheets in the smokehouse.

As regards factor (d) theoretically an increase in the closeness of packing of the sheets in the house tends to increase the period required for drying since the atmosphere inside the building is more moist. However, in practice the closeness of packing is not so great as to affect the rate of drying since as is seen from Table I B column (4), the weight of rubber per cubic foot of space is highest for the Devon smokehouse, yet the rate of drying is also high. That is to say, the closeness of packing of the sheets would have to be very great indeed in order to produce an appreciable decrease in rate of drying.

Ventilation of the House.

It will be seen that in the majority of cases exit for the damp air and smoke is provided at the top of the building by means of a jack-roof.

Material of Walls and of Roof.

In most cases the walls are of timber and the roof of corrugated iron or tiles.

Nature of Fuel.

In the large majority of cases, it will be noted that rubber wood alone is used as the fuel and to a less extent a mixture of rubber and jungle wood.

Temperature Registration Apparatus.

In almost all cases registration of the temperature inside the building is obtained by means of a maximum-and-minimum thermometer.

Depth of Colour of Cured Sheets.

It will be seen that the depth of colour of the cured sheets is in the large majority of cases described as medium.

Complaints re Mouldiness.

It is interesting to note that practically no complaints were received as to the mouldiness of consignments and it may be mentioned that the majority of estates reported that the use of para-nitrophenol as an antiseptic had been discontinued. During the restriction period a great deal of trouble was experienced with mould on smoked sheet, and hence it may be presumed that the present satisfactory state of affairs is due to the fact that estates are not now holding stocks for such a long period in the hot moist atmosphere of the tropics, which is very favourable to the growth of fungi.

Discussion of Results.

It has been made clear from the foregoing that the "Devon" type of smokehouse proved to be the most efficient of all those examined in this investigation. As houses of such design are well known and are described in detail by Morgan, (1) a few brief comments will here suffice. The special feature of the "Devon" type of building, as has already been pointed out lies in the provision which is made for wheeling with ease from the drying-chambers any of the racks holding the sheets outside on to a verandah without affecting the continuity of the smoke-curing of the sheets in the rest of the building-ing. There is thus no necessity to stop firing during filling and

emptying operations, which may be carried out with ease, ample space being provided on the verandah. The installation may consist of a single house with verandah or of two houses accommodated under one roof with a common verandah. It is a system which lends itself very easily to expansion, and is such that it can be used to deal with a crop of almost any size. It may be mentioned that the name merely indicates the design of the house and does not specify the material of the walls or roof, or the type of fire-chamber.

The "Third Mile" smokehouse consists essentially of a building having two storeys for accommodation of the rubber and a shallow inverted pyramidal base ending on the ground in a fire-chamber, the design of which is the chief distinguishing mark of this type. The fire-chamber itself is outside the building and consists of an iron cylindrical drum set horizontally in brickwork. At one end of the drum is a hinged door for stoking provided with adjustable air-inlets and at the other end a door for removal of the ash. The drum communicates with the interior of the building by means of a short chimney provided inside with a "damper" adjustable from the outside, and immediately over the chimney is suspended an iron baffle-plate. This system of firing is easy to operate and provided the doors fit fairly tightly the required amount of ventilation at the foot of the building is obtained by adjustment of the various air vents.

In what follows is given a summary of features of construction which should be common to all smokehouses including the special types just discussed. They are considered under appropriate headings.

General Design.

From the point of view of efficiency of ventilation a tall building is to be preferred, the height being greater than either the length or breadth. The height, however, is limited chiefly by the extent to which it is possible to maintain the required temperature of drying throughout the building and uniform colour of the product. If for example the house were of excessive height rubber in the lower storeys could be maintained at the desired temperature, but that in the upper would probably be far below the optimum conditions. Generally speaking, the number of storeys should not exceed three, the ground floor accommodating the fire-chambers and the upper two storeys containing the sheets.

There is also the question of size of the building. On a large estate, from a consideration of the risk of damage by fire, it is suggested that it is a safer policy to work with a larger number of small units than to accommodate the whole of the crop in one large building.

Ventilation.

The ideal to aim at is the production of a slow current of warm smoke-laden air passing from the bottom to the top of the building. The current should not be too rapid, since in that case the rate of of combustion of the fuel will be too great, dust would be raised from the ash formed, and the temperature of drying would be increased beyond the optimum limit. The draught should be just sufficient to carry off the moisture-laden air in the drying chambers. Since the required degree of ventilation can be obtained only as a result of practical experiment with the individual smokehouse, there should be sufficient provision for its adjustment. Ordinarily the construction of a smokehouse is not such as to render the lowest storey air-tight, air vents being unintentionally provided for example by chinks in the wall and round the edges of the doors. In order to minimise the risk of producing too great a draught, windows should not, therefore, be provided for the ground floor. Air-vents, provided with adjustable doors, which may be made to slide vertically in the apertures, should always be made at the base of the walls. As a guide it may be said that openings are made about 6 inches square at intervals of 4 feet all round the building. If not required the openings are kept closed, but in the majority of cases adjustment by means of such vents is a necessity. Another factor affecting ventilation at the base is the site of the building. If practicable the house should be situated on fairly level ground so that there is an open space for a considerable distance all round. When the smoke-house has to be placed on a steep gradient earth embankments should be cleared away in the immediate vicinity.

As regards ventilation at the roof, the top of the walls should fit tightly at the eaves of the roof, otherwise a counter current of air will at times be produced in the building. The construction of a low jack-roof over the main roof ridge provides a very simple and efficient method for the exit of the damp air and smoke. Alternatively chimney ventilators may be constructed, and if the fitting between the cap and body is sufficiently low interior swinging flaps for adjustment of the openings are not required. A ceiling should be provided protecting the whole of the racks and gangways and of such material that the condensation products of the smoke may be absorbed, thus preventing drops of tarry matter from falling on the sheets. For this purpose the ceiling is best made of wood; sacking would serve the same purpose without, however, being so permanant. One or more central openings in the ceiling, depending on the size of the building are provided for exit of the damp air and smoke to the roof ridge.

Constructional Materials.

The object in all drying houses is to conserve the heat as much as possible within the building. In this connection it is evident that different considerations enter into the choice of constructional materials in the case of smokehouses than in the case of crepe drying-sheds. In the latter case there is no internal heating installation, the heat being supplied from an external source by the sun's rays and hence crepe drying-sheds are constructed of a heat-conducting material such as corrugated iron. In the case of smokehouses constructed of corrugated iron additional benefit is obtained from the heat of the sun during the day but heat is rapidly dissipated outside the building during the night, when it is more difficult to ensure that the smokehouse attendant is keeping the fires going properly. Moreover the fires alone are capable of maintaining the temperature between the desired limits. Hence the use of non-conducting materials such as brick, wood or asbestos lining is recommended. The choice of constructional materials is of course regulated largely by questions of economy and in this connection it may be pointed out that timber soon becomes impregnated with tarry matter, the preservative properties of which confer a very long life on wooden walls, although there is then the risk of damage by fire to be considered. For the material of the roof brick tiles are very satisfactory provided they are fitted well together so that there is no leakage and so that ventilation is confined to the jack-roof or chimney ventilators on the roof ridge. For cleanliness of operation inside the building, the ground floor is best constructed of cement.

Fire-chambers.

The construction of the fire-chambers must be such as to ensure the slowest combustion of the fuel which is consistent with sufficient smoke production and the maintenance of the temperature between the required limits and it is known that the optimum temperature lies between 110° and 130° F. The choice of a fire-chamber depends therefore on the ease with which these conditions can be obtained. From this point of view probably iron drums or boxes either placed in contact with the ground floor or mounted on a trolley leave least room for errors in ventilation and require least attention in smoking, provided the sides and bottom are almost closed to the air. Special openings near the base are usually unnecessary and a door for stoking should not be made unless it fits closely round the edges. At the top is fitted a perforated iron plate or a cowl for distribution of the smoke. One or more of these boxes, depending on the size of the house, may be placed at intervals on the ground floor so as to give the most uniform distribution of heat and smoke. Greater freedom from dust in the building may be attained when the boxes are mounted

on wheels for removal outside for cleaning and stoking. This type of fire-chamber is suitable for use in a house of any size and particularly so in the case of small holdings where the building is often of a very temporary nature.

With brickwork ovens, whether stoked from the inside or outside, a hinged door must be fitted for cleaning and stoking and there is always difficulty in obtaining a closely fitting door. If this can be obtained, however, one or more "butterfly" ventilators should be provided in the door for provision of the required draught. Nothing elaborate is required for slow combustion fires and they should be built essentially on the same lines as iron boxes. The hearth may be of clay so as to make the fire-chamber completely closed to the air at the bottom. Obviously it is of advantage to arrange for stoking to be done from the outside of the building. Brickwork fire-chambers are of course more permanent than iron boxes but it is doubtful if the additional expense involved is justified except in the case of very large and permanent buildings.

Reference has already been made to the "Third Mile" type, the chief advantage of which lies in the ease with which efficient adjustment of the ventilation may be obtained.

The use of pits sunk in the ground floor as fuel containers is not to be recommended since they provide a small surface for the radiation of heat.

It will be seen from Table I A that in a few cases the fire-chamber itself is outside the building, the heat and smoke being distributed to the inside of the house by means of underground flues. Such an arrangement is very wasteful for not only is a considerable amount of heat dissipated during the passage of the hot gases from the fire-chamber to the interior but a certain amount of tarry matter from the smoke is condensed in the flues and smoke-curing is then much less efficient.

In the majority of cases iron baffle-plates suspended a few feet above the fire-chambers from the first floor are required for uniform distribution of the smoke within the building.

In all cases it is important to note that large fire-chambers are not desirable. The object should be rather to work with a larger number of small units than vice versa. Capacious fire-chambers require a bigger charge of fuel and slow combustion is not then easily attained. In small houses it is quite frequent to find that the fire-chamber is much bigger than is warranted by the size of the building. In illustration of this point a brief account is given below of an experiment which was conducted in a small smokehouse belonging to the Institute.

The installation is built on the lines of a small "Devon" smokehouse and has a capacity of about 1,500 lbs. per month, the average period of curing being 7 days. The fire-chamber consists of an iron

cylindrical drum with perforated lid placed centrally on the ground floor. Starting with a container approximately of the size of an ordinary 40 gallon oil drum, the smoke-house was filled with sheets to its maximum capacity, the temperature of drying being registered by a thermograph. The sheet was completely smoke-cured in 7 days the limits of temperature being 110° and 120° F. and the fuel consumption was 5.0 lbs. per lb. of dry rubber. The same drum was cut so as to reduce the height by about one third and the experiment repeated under the same conditions. In the two experiments the rubber wood fuel was air-dried before use, the ventilators were adjusted to the same position, and the smokehouse was filled to full capacity with sheets of approximately the same thickness in both cases. In the second experiment the fuel consumption was 2.7 lbs. per lb. of dry rubber, the period of curing being again 7 days.

Lastly it may be said that the test of slow combustion in any fire-chamber is the nature of the residue after the wood has burnt. The most desirable results are obtained when there is the least ash and most charcoal, provided of course that the required temperature has been maintained.

SMOKEHOUSES IN JAVA:—

It may be of interest to describe briefly the results obtained from fifty five estates in Java from a similar questionnaire by Dr. C. Knaus, published in Archief voor Rubbercultuur 12th Year No. 4, April 1928.

The consumption of fuel varied from 0.44 to 9.0 lbs. of fuel per lb. of dry rubber as shown below.

Type of smoke houses.	*Fuel consumed per lb. of dry rubber.*
Barker ...	1—2 lbs.
Old Coffee drying houses ...	1.5—9 ,,
Chamber system (outside furnace) ...	0.6—3.75 ,,
Chamber system (inside furnace) ...	0.7—6 ,,
Zimmerman system, ...	0.44 ,,

Twenty-two estates consume only from 1 to 1.5 lbs. of fuel per lb. of rubber, while another thirteen consume about 2 lbs. of fuel per lb. of rubber.

The temperature variations in the smoke house were from 35°C to 55°C=97°F to 131°F.

The smoking time and total drying time were as follows:—

Barker smoke houses, ...	6—9 days.	6—20 days.
Old Coffee drying houses, ...	6—14 ,,	9—14 ,,
Chamber system (outside furnace), ...	4—15 ,,	6—16 ,,
Chamber system (inside furnace), ...	4½—12 ,,	5—12 ,,

On 36 estates the smoking period was 9 days or less and on another 15 estates the period was from 10 to 12 days On seventeen estates, however, a supplementary drying was carried out.

It is concluded that the chamber type of smoke house, whether fitted with a Zimmerman heating installation, with ovens, smoke pots or fire trolleys is to be preferred.

Note:—The Zimmerman process consists of a hot water pipe system of drying plus an oven or smoke pot to produce smoke. The fuel consumption on the only estate on which this was installed is given as 44 lbs. per 100 lbs. of dry rubber which is low.

By comparing the results of the Malayan questionnaire with the results obtained in Java, it will be seen that both in respect of the amount of fuel used and the period of smoke-drying, the Malayan figures are very satisfactory, especially since no supplementary drying is carried out on estates in Malaya.

Conclusions.

Cleanliness in the smoke-curing process is as important as in other branches of factory practice. Where the fire-chambers are stoked from the inside of the building it is inevitable that dust is raised and to protect the sheets in the upper storey wooden frames fitted with wire gauze may be installed in the floor below each set of racks. The gauze must be cleaned and renewed from time to time.

The broties may be of bamboo or smooth hard wood, rotatable in grooves to enable different parts of the sheet to be placed in contact with the support, thus avoiding bar marks as much as possible. The minimum distance between the broties from centre to centre should be 3 inches since closer packing makes it difficult to keep the sheets apart from one another.

As regards the registration of the temperature the use of a self-recording thermograph has the advantage that it provides a check on the efficiency of the smokehouse attendant, who tends to heap on large fires instead of stoking frequently with small quantities of fuel.

The following factors are of importance:—

(1) Each day's production should be placed in a separate chamber in order to prevent wet and partially dried sheets being hung in the same space.

(2) The fire box should be arranged so that it can be easily attended and controlled.

(3) Sufficient gangways must be allowed for thorough inspection of all the sheets on the racks, or preferably an exterior verandah is provided, so that the racks can be removed from the smoke chamber for inspection.

(4) The smoke house must be constructed of solid material to avoid loss of heat and ventilation must be arranged so that the current

of hot moist air is upwards, by the provision of openings in the lower part of the smoke house, which can be regulated and a jack roof or roof ventilators.

Further work is in progress with the object of establishing the results obtained from this enquiry.

Acknowledgement.

I desire here to express my thanks for the valuable assistance given by those estates and estates' agency houses which took part in the enquiry.

References to Literature.

(1) "The Preparation of Plantation Rubber" by Morgan and Stevens.

TABLE I A.

1 Estate Number	2 Design of House	3 Design of Fire-Chamber	4 House Ventilation	5 Fire-box Ventilation	6 Material of Walls	7 Material of Roof	8 Temperature Registration Apparatus	9 Temperature Limits	10 Wood Fuel
1	Two Storeys	——	Jack-roof	—	Corrugated iron	Corrugated iron	Max. & Min. Thermometer	110°-130°F	Rubber only
2	Two Storeys	Fixed fire-box	Space between eaves of roof and walls	Open	Wooden planks	Corrugated iron	do	110°-120°F	Mixture of equal parts rubber and jungle
3A	Three Storeys	Internal brickwork chambers sunk in ground. Inside stoking	Jack-roof	Open	Wooden planks	Corrugated iron	do	110°-130°F	Jungle only
3B	Two Storeys	Fixed fire-box	Jack-roof	Open	Wooden planks	Corrugated iron	do	110°-130°F	Jungle only
4A	Three Storeys	Movable fire-box	Space between eaves of roof and walls	Through	Wooden planks	Corrugated iron	do	110°-120°F	Mixture of equal parts rubber and jungle
4B	Three Storeys	Movable fire-box	Space between eaves of roof and walls	Through	Wooden planks	Corrugated iron	do	110°-120°F	do
4C	Double Devon	Movable fire-box	Space between eaves of roof and walls	Open	Wooden planks	Chinese tiles	do	110°-120°F	do

TABLE I A—(contd.)

1	2	3	4	5	6	7	8	9	10
Estate Number	Design of House	Design of Fire-Chamber	House Ventilation	Fire-box Ventilation	Material of Walls	Material of Roof	Temperature Registration Apparatus.	Temperature Limits	Wood Fuel
5	Third Mile	Third Mile Type	Jack-roof	Through	Timber	Corrugated iron	Max. & Min. Thermometer	97°-125°F	Mixture 1 part jungle 2 parts rubber
6	Single Devon	Movable fire-box	Space between eaves of roof and walls	Open	Brick	Corrugated iron	Nil	110°-125°F	Rubber only
7	Third Mile	Third Mile Type	Jack-roof	Through	Timber	Tiles	Nil	100°-120°F	Jungle only
8	Third Mile	Third Mile Type	Jack-roof	Through	Timber	Tiles	Nil	100°F	Rubber only
9	Two Storeys	Brickwork-chambers. Inside stoking	Jack-roof	Through	Timber	"Italit"	Max. & Min. Thermometer	110°-115°F	Jungle only
10	Two Storeys	——	Holes at-top of walls under eaves of roof	—	Corrugated iron	Corrugated iron	Thermograph	110°-140°F	Rubber
11A	Two Storeys	Fixed iron fire-boxes	—	Open	Brick	Iron	Max. & Min. Thermometer	115°-145°F	Rubber
11B	Two Storeys	Fixed iron fire-boxes	—	Open	Brick	Iron	do	115°-145°F	Rubber

TABLE I A—(contd.)

1	2	3	4	5	6	7	8	9	10
Estate Number	Design of House	Design of Fire-Chamber.	House Ventilation	Fire-box Ventilation	Material of Walls	Material of Roof	Temperature Registration Apparatus	Temperature Limits	Wood Fuel
12	Three Storeys	Internal brick-work chamber. Outside stoking	Jack-roof and openings in walls under eaves of roof	Through	Brick	Chinese tiles	do	120°-135°F	Rubber
13	Three Storeys	Internal brick-chamber stoked from outside	Jack-roof	Through	Timber	Tiles	Nil	About 120°F	Rubber
14A	Two Storeys	Inside pit firing	Jack-roof	Open	Timber	Corrugated iron	Max. & Min. Thermometer	110°-120°F	Rubber
14B	Two Storeys	Inside pit firing	Jack-roof	Open	Timber	Corrugated iron	Max. & Min. Thermometer	110°-120°F	Rubber
15A	Three Storeys	External brick-work chambers with flue distributors	Jack-roof	Through	Timber	Corrugated iron	do	90°-130°F	Rubber
15B	Three Storeys	As in 15 A	Jack-roof	Through	Timber	Corrugated iron	do	90°-130°F	Rubber
16	Third Mile	Third Mile Type	Jack-roof	Through	Timber	Tiles	do	110°-120°F	Rubber

TABLE I A—(contd.)

1 Estate Number	2 Design of House	3 Design of Fire-Chamber	4 House Ventilation	5 Fire box Venti-lation	6 Material of Walls	7 Material of Roof	8 Temperature Registration Apparatus	9 Temperature Limits.	10 Wood Fuel
17	Double Devon	Movable iron fire-box	Jack-roof	Open	Timber	Tiles	Max. & Min. Thermometer.	About 110°F	Jungle
18	Third Mile	Third Mile Type	Jack-roof	Through	Timber	Tiles	do	90°-120°F	Rubber
19A	Third Mile	Third mile Type	Jack-roof	Through	Corrugated iron	Corrugated iron	do	100°-120°F	2 parts rubber and 1 part jungle
19B	Two Storeys	Internal brickwork chamber stoked from outside	Openings in roof controlled by flaps	Through	Corrugated iron	Corrugated iron	do	100°-120°F	Mixture 2 parts rubber and 1 part jungle
20	Two Storeys	Open fire	—	—	—	—	do	120°-130°F	Mixture of rubber and jungle
21	Two Storeys	Internal brickwork chamber stoked from inside	Space between eaves of roof and walls	Open	Timber	Corrugated iron	do	125°-135°F	Mixture of rubber and jungle
22	Third Mile	Third Mile Type	Jack-roof	Through	Timber	Tiles	do	110°-120°F	Jungle
23	Two Storeys	Fixed iron fire-box stoked from inside	Jack-roof	Through	Timber	" Italit "	do	110°-120°F	Mixture of rubber and jungle

TABLE I A—(contd.)

1	2	3	4	5	6	7	8	9	10
Estate Number	Design of House	Design of Fire-Chamber	House Ventilation	Fire-box Ventilation.	Material of Walls	Material of Roof	Temperature Registration Apparatus	Temperature Limits	Wood Fuel
24	Third Mile	Third Mile Type	Jack-roof	Through	Timber	Tiles	do	90°-120°F	Jungle
25A	Three Storeys	Fixed iron fire-box	—	Open	Timber	Iron	do	110°-120°F	Rubber
25B	Double Devon	Fixed iron fire-box	Jack-roof	Open	Timber	Tiles	do	110°-120°F	Rubber and jungle mixed
25C	Third Mile	Third Mile Type	Jack-roof	Through	Timber	Tiles	do	110°-120°F	Rubber and jungle mixed
26	Two Storeys	Internal brickwork chamber stoked from inside	—	—	Timber	Attap	Nil	—	Rubber
27	Third Mile	Third Mile Type	Jack-roof.	Through	Timber	Tiles	Max. & Min. Thermometer	100°-130°F	Mixture of rubber and jungle
28	Third Mile	Third Mile Type	Jack-roof	Through	Timber	Iron	do	100°-120°F	Rubber
29	Three Storeys	Brick fire-chambers sunk below ground level-Stoked from inside-covered with an iron cowl on top	Jack-roof	Open	Timber	Iron	do	130°-135°F	Jungle

TABLE I A—(cont.)

1 Estate Number	2 Design of House	3 Design of Fire-Chamber	4 House Ventilation	5 Fire-box Ventilation	6 Material of Walls	7 Material of Roof	8 Temperature Registration Apparatus	9 Temperature Limits	10 Wood Fuel
30	Third Mile	Third Mile Type	Jack-roof	Through	—	—	Thermograph	About 115°F	Rubber
31	Three Storeys	Fixed iron fire-boxes	—	Open	Timber	Tiles	Max. & Min. Thermometer	120°-130°F	Rubber
32	Two Storeys	Open fire sunk into ground floor	Chimney ventilators on roof	Open	Brick	Iron	do	About 125°F	Rubber
33A	Third Mile	Third Mile Type	Jack-roof	Through	Timber	Tiles	do	110°-120°F	Mixture of rubber and jungle
33B	Three Storeys	Internal brick fire-chamber stoked from inside—with ventilation door	Jack-roof	Through	Timber	Tiles	do	110°-120°F	Mixture of rubber and jungle
34	Two Storeys	External brick fire-chambers with under ground flue distributors.	Chimney ventilators on roof	Through	Timber	Tiles	do	About 100°F	Rubber
35A	Third Mile	Third Mile Type	Jack-roof	Through	Timber	Tiles	do	110°-130°F	Mixture of rubber and jungle

TABLE I A—(contd.)

1 Estate Number	2 Design of House	3 Design of Fire-Chamber	4 House Ventilation	5 Fire-box Ventilation	6 Material of Walls	7 Material of Roof	8 Temperature Registration Apparatus	9 Temperature Limits	10 Wood Fuel
35B	Double Devon	Movable fire-boxes running on rails under-ground	Jack-roof	Open	Timber	Tiles	Max. & Min Thermometer	110°-130°F	Mixture of rubber and jungle
36	Double Devon	Internal fire-chambers with adjustable ventilators	Chimney ventilators on roof	Through	Brick	Iron	do.	90°-120°F	Rubber
37	Third Mile	Movable fire-boxes running on rails under-ground	Jack-roof	Open	Timber	Tiles	do.	About 110°F	Jungle
38	Third Mile	Third Mile Type	Jack-roof	Through	Timber	Tiles	do.	About 110°F	Mixture of 1 part rubber & 1 part jungle
39	Double Devon	Third Mile Type	Jack-roof	Through	Timber	Tiles	do.	116°-140°F	Jungle
40A	Two Storeys	Fixed iron fire-boxes	Jack-roof	Open	Wood and iron	"Genasco"	Nil.	—	Rubber
40B	Two Storeys	Fixed iron fire-boxes	Jack-roof	Open	Wood and brick	Iron	Nil	—	Rubber

TABLE I A—(contd.)

1	2	3	4	5	6	7	8	9	10
Estate Number.	Design of House	Design of Fire-Chamber	House Ventilation	Fire-box Ventilation	Material of Walls	Material of Roof	Temperature Registration Apparatus	Temperature Limits	Wood Fuel
41	Third Mile	Third Mile Type	Jack-roof	Through	Timber	Tiles	Max. & Min. Thermometer	110°-120°F	Mixture of rubber and jungle
42	Three Storeys	Internal fire-chambers. Stoked from outside	—	Through	Iron	Iron	do	118°-128°F	Rubber
43	Two Storeys	Internal fire-chambers of brick. Stoked from outside	Jack-roof	Through	Brick	Iron	do	95°-130°F	Rubber
44	Two Storeys	—	—	—	Timber	Tiles	do	About 125°F	Mixture of rubber and jungle
45	Two Storeys	Internal fire-box	Adjustable ventilators on roof	Open	Brick and Timber	Iron	do	About 128°F	Rubber
46	Two Storeys	—	Chimney ventilators on roof	—	Iron	Iron	do	110°-125°F	Rubber
47	Three Storeys	Internal brick fire-chambers. Stoked from outside	Adjustable flap ventilators in ceiling	Through	Timber	Iron	do	90°-115°F	Rubber
48A	Third Mile	Third Mile Type	Jack-roof	Through	Timber	Tiles	do	About 120°F	Rubber
48B	Single Devon	Movable iron fire-boxes running on rails below ground level	Chimney ventilators on roof	Open	—	—	do	About 120°F	Rubber

TABLE I A—(contd.)

1 Estate Number	2 Design of House	3 Design of Fire-Chamber	4 House Ventilation	5 Fire-box Ventilation	6 Material of Walls	7 Material of Roof	8 Temperature Registration Apparatus	9 Temperature Limits	10 Wood Fuel
48C	Double Devon	As in 48B	As in 48 B	Open	Brick	Tiles	Max. & Min. Thermometer	About 120°F	Rubber
49	Third Mile	Third Mile Type	Jack-roof. Adjustable flap-ventilators in ceiling	Through	Timber	Tiles	do	116°-120°F	Rubber
50A	Double Devon	Internal fire-box	—	Open	Timber	Tiles	do	About 120°F	Rubber
50B	Single Devon	do	—	Open	Asbestos	Asbestos	do	100°-130°F	Rubber
51A	Single Devon	do	—	Open	Asbestos	Iron	do	About 120°F	Mixture of jungle and rubber
51B	Single Devon	do	—	Open	Iron	Iron	do	100°-130°F	Mixture of jungle and rubber

TABLE I B.

1	2	3	4	5	6	7	8	9	10
Estate Number	Design of House	Average Curing Period in Days	Capacity of Drying-Chambers: Weight of dry rubber in lbs. per cubic foot space	Monthly Output: Lbs. dry rubber per cubic foot drying space	Fuel Consumption: Lbs. Fuel per lb. dry rubber	Thickness of Sheet m.m.	Depth of Colour of Cured Sheet	Complaints re Mouldiness	Remarks
1	Two Storeys	7	0.9	3.9	1.5	2.0	Light	None	
2	Two Storeys	13	1.0	2.3	4.0	2.3	Medium	None	
3A	Three Storeys	9	0.7	2.3	2.0	2.7	Light	None	Fig. in Col. 6 calculated on 3A & 3B together
3B	Two Storeys	9	0.9	3.0	—	2.7	Light	None	
4A	Three Storeys	10	0.8	2.4	1.0	3.0	Dark	—	Fig. in Col. 6 calculated on 4A, 4B & 4C together
4B	Three Storeys	10	0.9	2.7	—	3.0	Dark	—	
4C	Double Devon	7	2.0	8.6	—	3.0	Dark	—	
5	Third Mile	14	1.1	2.4	1.6	—	—	None	
6	Single Devon	6	2.2	11.0	1.3	—	—	None	
7	Third Mile	11	0.8	2.2	—	3.1	Light	None	
8	Third Mile	7	1.4	6.0	—	.2	Medium	Few	

TABLE I B—(contd.)

1	2	3	4	5	6	7	8	9	10
Estate Number	Design of House	Average Curing Period in Days	Capacity of Drying-Chambers: Weight of dry rubber in lbs. per cubic foot space	Monthly Output: Lbs dry rubber per cubic foot drying space	Fuel Consumption: Lbs. Fuel per lb. dry rubber	Thickness of Sheet m.m.	Depth of Colour of Cured Sheet	Complaints re Mouldiness	Remarks
9	Two Storeys	10	1.6	4.8	0.9	2.9	Light	None	
10	Two Storeys	8	0.7	2.6	3.2	2.4	Medium	None	
11A	Two Storeys	13	0.7	1.6	1.8	2.6	Medium	None	Fig. in Col. 6 calculated on 11A & 11B together
11B	Two Storeys	16	1.0	1.9	—	2.6	Medium	None	
12	Three Storeys	8	1.0	3.8	1.3	2.7	Medium	None	
13	Three Storeys	9	1.1	3.7	0.5	2.5	Light	None	
14A	Two Storeys	8	1.0	3.8	1.1	3.3	Medium	None	
14B	Two Storeys	13	1.0	2.3	4.0	3.3	Medium	None	
15A	Three Storeys	15	1.0	2.0	1.1	3.1	Medium	Few	
15B	Three Storeys	15	1.0	2.0	0.8	3.1	Medium	Few	
16	Third Mile	12	1.5	3.8	0.5	2.8	Medium	None	

TABLE I B—(contd.)

1	2	3	4.	5	6	7	8	9	10
Estate Number	Design of House	Average Curing Period in Days	Capacity of Drying-Chambers: Weight of dry rubber in lbs. per cubic foot space	Monthly Output: Lbs. dry rubber per cubic foot drying space	Fuel Consumption: Lbs. Fuel per lb. dry rubber	Thickness of Sheet m.m.	Depth of Colour of Cured Sheet	Complaints re Mouldiness	Remarks
17	Double Devon	7	1.0	4.3	1.0	—	—	None	
18	Third Mile	8	1.3	4.9	0.6	2.6	Medium	Few	
19A	Third Mile	10	1.4	4.2	1.3	2.9	Medium	Frequent	
19B	Two Storeys	10	0.8	2.4	1.5	2.9	Medium	Frequent	
20	Two Storeys	11	0.8	2.2	3.8	3.2	Medium	Few	
21	Two Storeys	9	1.1	3.7	0.8	3.0	Medium	—	
22	Third Mile	9	—	—	1.0	2.9	Light	None	
23	Two Storeys	10	1.7	5.1	0.8	3.7	Medium	—	
24	Third Mile	12	2.2	5.5	0.8	3.0	Medium	None	
25A	Three Storeys	15	0.9	1.8	2.3	2.4	Medium	None	
25B	Double Devon	10	—	—	1.5	2.4	Medium	None	
25C	Third Mile	12	0.9	2.3	1.0	2.4	Medium	None	

TABLE I B—(contd.)

1	2	3	4	5	6	7	8	9	10
Estate Number	Design of House	Average Curing Period in Days	Capacity of Drying-Chambers: Weight of dry rubber in lbs. per cubic foot space	Monthly Output: Lbs. dry rubber per cubic foot drying space	Fuel Consumption: Lbs. Fuel per lb. dry rubber	Thickness of Sheet m.m.	Depth of Colour of Cured Sheet	Complaints re Mouldiness	Remarks
26	Two Storeys	13	0.9	2.1	2.5	—	—	Frequent	
27	Third Mile	7	1.0	4.3	1.1	1.8	Medium	Few	
28	Third Mile	10	0.8	2.4	1.0	3.3	Medium	None	
29	Three Storeys	8	—	—	3.0	2.6	Light	None	
30	Third Mile	7	—	—	2.1	3.0	Medium	None	
31	Three Storeys	10	1.4	4.2	0.8	3.7	Medium	None	
32	Two Storeys	10	0.9	2.7	1.5	2.7	Medium	None	
33A	Third Mile	12	1.5	3.8	3.0	3.6	Medium	None	
33B	Three Storeys	12	1.4	3.5	1.2	3.6	Medium	None	
34	Two Storeys	10	1.6	4.8	1.0	3.7	Medium	None	
35A	Third Mile	10	1.2	3.6	0.5	2.8	Medium	None	

TABLE I B—(contd.)

1	2	3	4	5	6	7	8	9	10
Estate Number	Design of House	Average Curing Period in Days	Capacity of Drying-Chambers: Weight of dry rubber in lbs. per cubic foot space	Monthly Output: Lbs. dry rubber per cubic foot drying space	Fuel Consumption: Lbs. Fuel per lb. dry rubber	Thickness of Sheet m.m	Depth of Colour of Cured Sheet	Complaints re Mouldiness	Remarks
35B	Double Devon	10	2.1	6.3	1.0	2.8	Medium	None	
36	Double Devon	7	1.7	7.3	0.6	2.8	Medium	None	
37	Double Devon	7	1.2	5.1	1.6	2.0	Medium	None	
38	Third Mile	11	1.9	5.2	1.5	3.6	Medium	None	
39	Third Mile	8	1.2	4.5	0.8	2.7	Medium	None	
40A	Two Storeys	13	—	—	0.8	2.2	Medium	None	
40B	Two Storeys	13	—	—	0.8	2.2	Medium	None	
41	Third Mile	12	1.3	3.3	0.6	3.2	Medium	Few	
42	Three Storeys	10	0.9	2.7	1.3	2.7	—	None	
43	Two Storeys	10	0.9	2.7	2.0	—	—	—	
44	Two Storeys	11	1.0	2.7	1.7	2.9	Medium	Frequent	

TABLE I B—(contd.)

1	2	3	4	5	6	7	8	9	10
Estate Number	Design of House	Average Curing Period in Days	Capacity of Drying-Chambers	Monthly Output	Fuel Consumption	Thickness of Sheet m. m.	Depth of Colour of Cured Sheet	Complaints re Mouldiness	Remarks
			Weight of dry rubber in lbs. per cubic foot space	Lbs. dry rubber per cubic foot drying space	Lbs. Fuel per lb. dry rubber				
45	Two Storeys	11	1.5	4.1	2.2	3.1	Medium	None	
46	Two Storeys	12	1.0	2.5	2.0	3.0	Medium	None	
47	Three Storeys	20	1.3	2.0	3.0	3.8	Medium	None	
48A	Third Mile	12	1.3	3.3	1.6	3.5	Medium	None	Fig. in Col. 6 calculated on 48A, 48B & 48C together
48B	Single Devon	18	1.7	6.4	—	3.5	Medium	None	
48C	Double Devon	18	1.7	6.4	—	3.5	Medium	None	
49	Third Mile	9	1.0	3.3	1.0	—	Medium	None	
50A	Double Devon	9	1.8	6.0	2.0	—	Medium	None	Fig. in Col. 6 calculated on 50A & 50B together
50B	Single Devon	7	1.6	6.9	—	—	Medium	None	
51A	Single Devon	8	1.6	6.0	1.3	—	Medium	None	Fig. in Col. 6 calculated on 51A & 51 B together
51B	Single Devon	8	1.6	6.0	—	—	Medium	None	

RUBBER RESEARCH IN CEYLON (1929).

The Annual Report of the Rubber Research Scheme of Ceylon for 1929 constitutes the Eighth Report of the Executive Committee to the Members of the Rubber Research Scheme and contains:—

(1) The Report of the Executive Committee in Ceylon.
(2) The Report of the Organising Secretary on visits to estates.
(3) The Chemist's Report.
(4) The Physiological Botanist's Report.
(5) The Mycologist's Report.
(6) Report of the London Advisory Committee.

In addition there is an Appendix to the Annual Report of the London Advisory Committee, a list of members of the Scheme, Income and Expenditure Account for 1929 and Estimates of Income and Expenditure for 1930.

It is proposed in this review to deal primarily with the scientific work carried out under the scheme so that planters and others in Malaya who are interested in rubber cultivation may know the nature and results of investigations carried out in Ceylon.

Replanting and Rejuvenation of Old Rubber Areas.

A tentative scheme of experiments has been discussed and it has been decided to remove completely all trees in areas which are to be replanted and to experiment with tapping-to-death methods over a period of three months, in order to obtain the maximum yield from the old trees before their removal.

The possibility of converting the rubber wood from the old trees into Adco synthetic farmyard manure has also been considered and small scale experiments are being carried out.

Rubber Budding and Seed Selection.

A pamphlet is being prepared by the Physiological Botanist for the guidance of planters. Special attention is being given to the selection of mother trees on estates. Ninety estates are supplying budwood and keeping records of yields of mother trees. The establishment of isolated seed gardens has been delayed by the lack of available land, but it is anticipated that this will be remedied shortly.

Manuring Problems.

In the manuring experiments previously laid down the lay-out did not allow of statistical treatment of the results by the latest methods and no significant increase in yield of rubber was recorded.

Definite benefit on foliage and bark renewal, however, as a result of nitrogenous manuring alone or in combination with phosphates and potash was obtained. A scheme for a further manuring experiment covering a period of ten years has been drawn up and adopted.

Cover Crops.

Calapogonium mucunoides and *Centrosema pubescens* have proved the most successful of the low growing cover crops.

A number of indigenous plants found growing naturally, including three species of Desmodium, have been utilised. (This is of interest, since two species of Desmodium, indigenous to Malaya, have been established at the Institute's Experiment Station.) The herbaceous taller leguminous plants—*Crotalaria usaramoensis, Tephrosia candida, Clitoria cajanifolia* and *Indigofera arrecta* also grow well as they do in Malaya.

Diseases.

Brown Bast.

The results of scraping combined with the isolation method advocated by Keuchenius have been successful when carried out carefully.

An experiment on the isolation method, without scraping, was not successful, when an area of bark of more than a few inches in diameter is affected. The spread of the disease is stopped but a cure is not effected. Isolation without scraping is recommended when it is observed that no great length of the tapping cut has gone dry.

Oidium Leaf Disease.

This disease is a serious menace to rubber trees in some districts and is more prevalent than in 1928. It is concluded that there is little correlation between rainfall and the incidence of the disease but that a relatively dry atmosphere, by favouring the production of spores, is conducive to severe attack. Trees growing in poor soil and on exposed ridges suffer more severely than trees in valleys on richer soils. (This agrees with observations in Malaya on the incidence and virulency of the attack. A long dry spell during the refoliation period after normal wintering has affected the incidence and extent of the attack in Malaya.)

There is no evidence of any inherent individual immunity or resistance to the disease and any tree which produces its young leaves at a time when the fungus is active will be attacked.

Experiments to test the effect of manuring (particularly the application of nitrogenous and potash fertilizers) as a means of in-

creasing the resistance of the leaf to infection have been commenced. Arrangements to carry out tests on spraying with Sulfinette and sulphur have also been made.

Diseases of Bud Shoots.

A new disease of young shoots of budded rubber has been investigated and a strain of *Phytophthora Palmivora* is stated to be the causal organism.

This disease has originated on material imported from Java and is thought to have been introduced from that country.

In view of the above, it has been considered desirable to find an effective and harmless method of disinfection of such imported material and experiments have been commenced. (Note:—In the Report of the Second Imperial Mycological Conference held in England in 1929, the attention of the Governments of Malaya and Ceylon is being drawn to the desirability of disinfection of imported rubber budwood, stumps, seeds, etc., and the matter is under consideration in Malaya. B.J.E.).

Root Diseases.

The general position in respect of root diseases of rubber in Ceylon is considered satisfactory. Improved methods of treatment practised on most estates have proved effective in preventing the spread of *Fomes lignosus* and securing its eradication.

Ustulina zonata continued to be prevalent but in many cases a tree-to-tree examination has resulted in detection at an early stage. The concrete filling method advised has proved very successful.

"Rust" on Vigna.

The "rust" disease of Vigna caused by *Uromyces sp.* has been further investigated and it is concluded that the leaf-fall caused by the disease can be a serious factor in the destruction of this cover crop, especially under dry weather conditions, but the Vigna recovers on the advent of wet weather.

(Note:—In this connection it is of interest to remark that owing to diseases, *Centrosema pubescens* is being used extensively in Sumatra to replace Vigna, B.J.E).

Snails (Achatina Fulica).

In view of the interest which has been taken in connection with the appearance of the giant snail in Malaya, it is noted that this continues to do much damage to areas of Vigna in Ceylon and that no satisfactory method of control has yet been devised in Ceylon.

Preparation of Raw Rubber.

Sheet Rubber.

On account of shortage of wood fuel investigations are being carried out on methods of drying and curing sheet rubber other than by smoking.

The chief disadvantage of hot-air drying is that the surface of the sheet becomes sticky, but methods of eliminating this have been discovered (Note:—Similar observations have been made at the Rubber Research Institute).

Spot disease of Crepe Rubber.

The addition of para-nitrophenol to latex in the preparation of crepe has been advocated in order to prevent "spot" disease caused by the growth of fungi. It has been found that discoloration of the crepe by para-nitrophenol only occurs if the crepe is exposed to direct light during drying.

A fungicide known as Mouldex recommended for the treatment of sheet rubber for the prevention of moulds, has been investigated and found to be less effective than paranitrophenol which is now used. (Note:—This agrees with the result of investigations made in the laboratories of the Rubber Research Institute. B.J.E.) It was also found to be unsuitable for the treatment of crepe rubber, owing to the colour imparted to the product.

Experiments on the effect of iron in water on the colour of crepe rubber indicated that small proportions of iron are likely to have an important detrimental effect.

Investigations at the Imperial Institute.

A memorandum was drawn up containing details of the various methods of vulcanisation and testing of rubber and this was used as a basis for discussion at the Rubber Conference in Java. (As stated in the Annual Report of the Rubber Research Institute of Malaya, 1929, arrangements were made at this Conference for a series of tests on the lines indicated to be carried out at the Imperial Institute, at the Central Rubber Proefstation, Buitenzorg, Java, and at the Rubber Research Institute in order to compare the results obtained at the three stations).

A series of experiments were carried out with the object of recommending methods for improving the uniformity of rubber in Ceylon.

An intensive study of variation in plasticity of first grade plantation rubber is also being made.

REMARKS.

The results of the above investigations indicate that research work in Ceylon and Malaya is being carried out on similar lines, except where local conditions differ. The results are also in accordance with those obtained in the investigation of similar problems in Malaya.

ORGANISATION.

It may be of interest to those interested in the organisation of rubber research in Malaya to add the following details in respect of the organisation and finance of the Rubber Research Scheme of Ceylon.

Under the present organisation, the Scheme is maintained by means of graded voluntary subscriptions from estates in Ceylon based on output of rubber, although estates not yet producing have to contribute 10 guineas a year in order to join the Scheme. Estates yielding a crop exceeding 700,000 lbs. contribute 50 guineas a year.

In addition, the Rubber Growers' Association contributes £2,000/- a year and the Ceylon Committee about £500/- a year for the investigations carried out in the vulcanising laboratories at the Imperial Institute, London, in connection with problems of preparation of raw rubber. The Government of Ceylon also contributed Rs. 67,500/- in 1929.

An Ordinance is under consideration by the Government of Ceylon for the future maintenance of the Scheme by means of the imposition of a cess on all rubber exported from Ceylon, similar to the method already adopted in Malaya for the maintenance of the Rubber Research Institute of Malaya.

B.J.E.

SECOND IMPERIAL MYCOLOGICAL CONFERENCE 1929.

In the Report of the Second Imperial Mycological Conference, 1929, recently published, the following details are of particular interest

A resolution (No. 5) adopted by the Conference suggests that the attention of the Governments of Malaya and Ceylon should be drawn to the desirability of investigating the possibility of treating budwood against diseases before import.

In relation to this, it is of interest to note in the Annual Report of the Rubber Research Scheme of Ceylon (1929), which is reviewed in this Journal, a reference to investigations which are being carried out in Ceylon for dealing with the disinfection of such material. Steps have already been taken in Malaya for a discussion of the problem, with a view to any necessary action.

It is also of interest to note Resolution No. 7 which reads as follows:—

"The Conference is of opinion that the system of Certificates is one which should be universally recognised but that the acceptance of such certificates should not be allowed to imply that importing countries should in any way waive their rights of prohibiting, inspecting, treating, quarantining and destroying where necessary, plant imports. It further recommends that steps should be taken to arrange that exporting countries within the Empire should specify as nearly as possible the significance of their certificates covering plant exports."

A form of certificate was drawn up for adoption and approval within the Empire.

Another important resolution (No. 8) recommends that countries between which planting material frequently passes should endeavour to group themselves together and investigate the possibility of finding a minimum treatment for any specific pest or disease of a particular plant of which the export is desired.

In resolution No. 6 the Conference also recommends that provision be made for necessary work to be undertaken by the Imperial Bureau of Mycology for notification (and by Tropical Colonies for group notification) of information in regard to the distribution of diseases of crop plants throughout the world.

Resolution (No. 2) accepts the report of a Committee appointed to consider the need for a series of handbooks on the diseases of tropical and subtropical crops and recommends that it be referred to the Managing Committee of the Imperial Bureau of Mycology for such action as may be necessary.

In each handbook, it is recommended that special attention should be devoted to the following:—

(a) The relation of diseases to varied agricultural practice.

(b) Varietal resistance to diseases naming resistant varieties in detail.

(c) Agricultural methods of control as distinct from methods such as spraying and dusting.

(d) Good illustrations and accurate descriptions of each disease.

The handbooks should also indicate gaps in our knowledge of the disease or in the development of control measures, thus suggesting lines for future research.

The Committee of management of the Imperial Bureau of Mycology considers that the Handbook on Rubber diseases should be prepared by a member or members of the staff of the Rubber Research Institute of Malaya provided this course is considered satisfactory by the Government.

In relation to the Conference papers, it is to be regretted that one paper on "Methods of obtaining standardised proprietary disinfectants, with special reference to (a) coal tar derivatives (b) mercury compounds, was not presented and discussed.

In view of the large number of proprietary fungicides which are marketed and recommended from time to time, it would appear that an investigation of the relative value of these fungicides for specific diseases and a comparison with some well-defined standard is desirable.

B.J.E.

EXPERIMENT STATION, SUNGEI BULOH.

Notices.

Visitors.

Owing to the large number of visitors to the Experiment Station, it has been decided to restrict visiting days at present to Wednesdays. Applications to visit should be made to the Director or to the Chief Field Officer of the Rubber Research Institute, Kuala Lumpur. The Chief Field Officer, when available, will accompany visitors to the Experiment Station.

Visitors' Bungalow.

A bungalow for visitors is now available at the Experiment Station, so that planters or others who wish to study budding or other planting operations can stay for one or more nights or can obtain meals at a fixed tariff.

Applications for use of the bungalow should be addressed to the Director or to the Chief Field Officer at the Institute.

Hostel.

A hostel for estate conductors is also available. Estate conductors can be accommodated for one or more nights, but must make their own arrangements for feeding. A shop is available on the estate from which foodstuffs and drinks can be purchased if required.

A bed and mosquito net are provided in each room, but conductors must bring their own sheet or blanket and pillow.

Applications for the accommodation of conductors at the hostel should be made by managers of estates, and addressed to the Director or to the Chief Field Officer of the Institute, Kuala Lumpur.

Budding Operators.

Budding labour is available at the Experiment Station for loan to estates. The charges are as follows:—Mandor $1/50 per day, Budding coolies $1/- per day, plus return travelling expenses from the Station to the estate.

Budding conductors can also be obtained on loan for a day or two without charge, but all travelling expenses must be paid by the estate requiring their services.

All materials must be supplied by the estate.

Applications for the loan of the services of the above should be addressed to the Manager, Rubber Research Institute Experiment Station, Sungei Buloh, Selangor.

23rd June, 1930.

REVIEW.

Principles of Tropical Agriculture

by

H. A. Tempany, D.SC., F.I.C., F.C.S. and G. E. Mann, M.A.

This book which is published under the auspices of The Incorporated Society of Planters, Malaya consists of twenty chapters of 328 pages, together with a bibliography, index and 25 illustrations. The book is conveniently divided into two parts (1) Limiting factors in crop production, (2) Agricultural Practice.

As is well known the senior author has had a long and wide experience of tropical agriculture, as Director of Agriculture in the West Indies, Mauritius and more recently in Malaya and is one of the world's authorities on sugar cane cultivation, while the other author has had considerable experience in instructing Malay Students in the applications of science to the art of agriculture.

The principles of agriculture are essentially the same in temperate, sub-tropical and tropical countries, but the methods of application of these principles differ considerably in the various agricultural regions of the world owing to climatic and other factors. The second part of this book on agricultural practice, therefore, applies particularly to tropical agriculture.

Students of tropical agriculture will be especially interested in Chapter IV on the climate of the Tropics, which is such an important factor in tropical agriculture, although the whole of Part I conveys a sound knowledge of the many factors which influence crop production in all countries.

The second part of the book on Agricultural Practice will enable the student to appreciate how these limiting factors may be overcome or their effects reduced. The practical planter or farmer does not always realise the limitations imposed on the scientific agricultural adviser by the conditions on the estate or farm. Scientific advice is limited by the question of economics. Improvements can be effected on practically all cultivated areas by appropriate treatment, but the application of the methods recommended depend frequently on the cost of the method, the rate at which improvement can be effected and the value of the crop obtained as a result of the method of treatment.

Two interesting and valuable chapters in Part II are those dealing with Plant Pests and Diseases and the Economics of Crop Production in the Tropics.

Information on these important agricultural problems is frequently omitted or discussed in a few paragraphs in books of this nature.

The influence of ethnographical factors on agriculture, for example, is to be seen particularly in a densely populated country such as Java.

In no other art or industry are so many factors concerned as in the art of agriculture and in many respects the application of scientific knowledge to this industry is in its infancy.

The authors are to be congratulated on their efforts in compiling a valuable textbook, which should be in the hands of all planters. It can be recommended also for the use of agricultural educational institutions.

The book is well printed and is remarkably cheap at the price of $4/50.

B.J.E.

EDITORIAL.

The Use of Asphalts and Bitumens on Estates.

The problem of the most suitable substance or mixture for application in connection with tree surgery is of considerable importance. Tars of various origin and variable composition with and without the addition of fungicides have been used generally on wounds caused by wind break or by pruning, for treatment of various stem and branch diseases, and the cutting of the stock in budding operations.

The chief disadvantage of plain tar and of the mixtures usually employed is their effect on the bark and cortex due to penetration. Another disadvantageous factor is that these mixtures when dry are liable to flake off, thus allowing water to enter the wound surface which facilitates the growth of wood destroying organisms.

The experiments described, in which mixtures of asphalt or bitumen with kerosene or with various fungicides have been tried, indicate that a very satisfactory and economical product can be made, which on account of its elastic properties does not flake off when dry. The mixtures have been applied with satisfactory results in estate practice.

Non-Caoutchouc Constituents of Latex.

Investigations on the non-caoutchouc constituents of latex have led to the isolation of a substance that may be described as a plant lipin. It is shown to have a very definite effect on the behaviour of raw rubber on the mixing rolls and during vulcanisation.

Although valuable work has been carried out by various workers on the non-caoutchouc constituents of Hevea latex and of the raw rubber derived from it by coagulation, much still remains to be done on the isolation and investigation of these substances.

The influence of some of these substances, which occur in the latex only in small quantity, has a most important effect on the quality and properties of raw rubber during vulcanisation and for that reason alone it is essential to continue investigation.

Apart from the above, however, these substances may be found to be of importance in relation to the physiology of latex production and the metabolism of the tree.

Bacteriology of Latex.

Further notes on the diagnostic characters and behaviour under different conditions of a number of micro-organisms isolated from samples of latex from different districts of Malaya are published by

Dr. Corbet and constitute a useful supplement to Bulletin No. 1, "The Natural Coagulation of Hevea Latex" by the same author published by the Institute in 1929.

The results of the investigation are of value in relation to the phenomenon of natural coagulation of latex, the preservation of latex, the use of anti-coagulants and the inhibition of bubble formation in sheet rubber.

Coagulation Phenomena with Acids.

Considerable attention has been devoted by various workers during recent years to coagulation phenomena of colloids including latex. The investigations have shown that the phenomenon of coagulation is of a physico-chemical nature and is related to the hydrogen ion concentration of the latex.

It is not possible to describe these investigations in a language which is very intelligible to the non-scientist who may, therefore, not appreciate the full significance of the work and its results. It may be stated, however, that such investigation is of fundamental importance in studying the properties of latex particularly the problems of coagulation, preservation and concentration.

The difficulties of determining the hydrogen ion concentration (pH value) of latex have now been overcome by the application of electrometric methods as described in this journal. Colorimetric methods of determination are not entirely satisfactory owing to the opacity of latex and the absorptive properties of the caoutchouc globules which obscure colour changes. Further the colorimetric method is less accurate.

It may be of interest to state here that a very elaborate and lengthy thesis on this subject has recently been published by Van Harpen of the A.V.R.O.S. Proefstation, Sumatra. The work carried out by Mr. Fullerton has, therefore, been carried on *pari passu* with the work in Sumatra.

Further investigation on the constituent in latex which appears to be responsible for carrying the phenomenon of coalescence to the stage of coagulation is still necessary. This substance is probably a fatty acid or resin present in the so called "resin" or acetone extract of raw rubber.

Oidium Heveae.

Further observations on *Oidium Heveae* which causes the mildew disease of the rubber tree indicate that this fungus is probably carried over from one dry season to the next on the flowers of the tree.

Silt Pitting on Estates in Relation to Mosquito Breeding and Malaria.

This article is published at the request of the Malaria Advisory Board and gives the conclusions arrived at by a committee appointed by this body on which this Institute was represented by Dr. W. B. Haines, Head of the Soils Division.

The conclusions demonstrate that agricultural improvements on estates in respect of methods of soil conservation and drainage need not be antagonistic to the requirements demanded by health regulations for the prevention of the breeding of mosquitoes which are carriers of malarial parasites.

Information Cards.

Attention is drawn to the note on the publication and issue of Information Cards dealing with various aspects of estate factory practice and defects in raw rubber.

Each card deals with one problem, e.g. Card No. 1, C, contains "Directions for coagulating Latex". Card No. 2, C, deals with "Sodium sulphite".

Judging from the demands for these cards, they are serving a useful purpose.

THE USE OF ASPHALTS AND BITUMENS ON ESTATES. (1).

BY

H. SUTCLIFFE.

Asphalts or Bitumens derived from crude petroleum are amongst the earliest products used by mankind. Spielmann (1) in his Historical Introduction to Bituminous Substances points out that bitumen has long been known and used for ornamentation and for rendering vessels watertight. The Sumerians, 6000 B.C. to 7000 B.C. had a considerable artistic ability and ornamented their vessels with bitumen as cementing material. The Persians also used bitumens as a cementing material in the eye-sockets of the figures of animals. One of the earliest records of the use of bitumens as a waterproofing material is the account given in the Bible of the caulking of Noah's Ark before the Flood. Bitumen was also used as a waterproofing material in the cities of Babylon and Nineveh for cementing together bricks and stones. Wooden buildings were also treated with bitumen not only as a protection against bad weather conditions but also as a wood preservative. The bitumen was obtained from the valley of the Dead Sea and was collected from the Dead Sea itself. It was also collected from the river Euphrates and from the wells nearby.

In more recent times the asphalts and bitumens are well-known materials in modern road making. In addition to this they are used for waterproofing such materials as felt for roofs, waterproofing fabrics and papers, in the preparation of waterproof paints and cements and electrical insulation materials. In American forestry, asphalts, bitumens or asphaltic or bitumistic compounds have been used for treating wounds and for tree repair.

Asphalts and bitumens are neither liquids nor solids as these are ordinarily understood but a mass of road asphalt placed on a table will flow until it forms a flat layer. The two substances have no definite melting points and although they seem dry and unwettable yet Trinidad asphalt contains nearly 30 per cent. of water which is in such a condition that there is no indication of its presence in the asphalt.

Use on Estates.—It is customary on estates after pruning branches to paint the wounds with some kind of plain tar. Some estates, however, use a mixture of tar and " Solignum ", " Jodelite ", " Dougalite ", " Brunolinum " or similar proprie-

tary preparations in varying proportions. The same materials are also used for treating old cases of "Pink Disease" or for treating trees to prevent the attacks of boring beetles on bark which has been damaged by fire. Tar or tar mixtures have also been used in painting the wounds on roots after treatment of root diseases. Tars and the various tar mixtures have the disadvantage of cracking and flaking away or drying thus allowing the entry of water, followed by fungi and bacteria which begin to attack the exposed wood and cause its decay. In fact the great majority of rot producing fungi and bacteria can only make their entry into the tree through unprotected wounds especially on the aerial parts.

As asphalt or bitumen does not crack or flake off but merely stretches, when applied to a growing surface, and in addition has the valuable property of being waterproof this seems an ideal material for use on estates in place of tar or mixtures of tar with disinfectants. To this end experiments were made with various mixtures of asphalt and kerosene as well as asphalt with disinfectants and wood preservatives, applied to the stems of young rubber plants one to two years' old.

Table I shows the various penetrations at different heights and with various bark and cortex thickness. The term "sclerenchyma ring" is applied to a continuous ring of stone cells which is found in the virgin bark of every rubber tree. It is formed originally in the seedling as a continuous ring of bast fibres, and as the seedling increases in thickness this ring becomes broken but continuity of the ring is maintained by the formation of stone cells from some of the ordinary cells near the original ring. Thus the ever-widening ring comes to be composed largely of stone cells with here and there the now isolated bast fibres which formed the original ring. These bast fibres persist and can still be found in the virgin bark of the oldest rubber tree, and are distinguished from the stone cells by their characteristic concentric circles in transverse section. No latex vessels are ever found outside this ring and it is thus a measure of the extent of the latex vessel system. Any tar, disinfectant or mixture of tar and disinfectant or wood preservative which penetrates beyond the sclerenchyma would be liable to cause damage to the tree.

For most of these tests a semi-solid asphaltum was selected as likely to contain a minimum amount of volatile and water soluble constituents and other impurities. Such a substance requires a carrier—a liquid medium—in order to render the asphaltum applicable without heat. The choice of a carrier was decided by its cheapness and effectiveness, the facility with which it could be obtained and its action on the plant tissues.

The following liquids have been experimented with as carriers—Kerosene, Brunolinum, Dougalite, crude creosote, Solignum, Jodelite, Noxo, wax and vaseline, Agrisol; not all of these mixtures have been described in the present paper. It should be noted that in order to make the mixtures the asphaltum must first be melted. It is most important that the asphaltum is not over heated as by doing so its properties may be considerably altered and its efficiency reduced. The heating should only be sufficient to cause the asphaltum to liquefy completely and the mixture should be stirred until it is of uniform consistency. Any mixtures which are stored should be kept air-tight to prevent evaporation of the kerosene, and, if stored for some considerable time, it may be necessary to warm and add a little more of the carrier before using again.

Asphaltum alone is a very inert substance and has the unique property of allowing the use of carriers, the penetration of which, when used alone, renders them quite unserviceable. This fact is clearly established by the penetration tests.

It will be noticed that the penetration is less on the thinner parts of the cortex and bark and is never beyond the sclerenchyma ring. On the green parts of the stem the mixtures mostly do not penetrate beyond the cuticle. "Bark thickness" includes the outer corky bark together with the cortex down to the cambium while "Cortex thickness" includes the cuticle and cortex down to the cambium in the seedlings. The distance of the sclerenchyma ring is measured from the cuticle and from the outside of the bark.

Costs. The following figures shows the cost of asphalts, disinfectants, kerosene oil, etc. It will be noticed that some of the asphalt mixtures not only compare favourably in price with Singapore tar at 47.5 cents. per gallon but have the additional advantage of being more or less standard and would show practically no variation as regards penetration or burning as is often shown by different consignments of tars. Another advantage of asphaltic mixtures over tars is that they are more economical in use as only thin films are necessary to form a water-proof covering so that large areas can be covered with a small quantity of material. In the event of the mixtures becoming too thick owing to the evaporation of kerosene the proper consistency can be easily obtained by the addition of a little more kerosene oil.

Although only two typical proprietary disinfectants are given, probably other non-water-soluble disinfectants as "Solignum," "Jodelite," "Noxo," etc. could be used, but their use would naturally be governed by the price.

At a later date it is intended to publish further series (Nos. 2, 3 etc.) on this subject dealing with preparations not tested nor described in the present paper.

TABLE I

Expt.	MIXTURE.				Diameter of Seedling mm.	Thickness of Cortex. mm.	Thickness of Sclerenchyma ring. mm.	Penetration.		Remarks.
	Asphalt DX per cent.	Kerosene per cent.	Brunolinum per cent.	Dougalite per cent.				Average. mm.	Greatest. mm.	
1	50	50	—	—	3.8	0.25	0.15	Nil. Cuticle not penetrated. Film only formed on the cuticle.		
	,,	,,	—	—	12.0	0.87	0.37	0.14	0.21	
2	66.7	33.3	—	—	3.6	0.24	0.15	Nil. Film only formed on the cuticle.		
	,,	,,	—	—	9.5	0.73	0.41	0.26	0.31	
3	44.4	55.6	—	—	3.7	0.27	0.13	Nil. The mixture forms surface layer on cuticle.		
	,,	,,	—	—	12.4	0.85	0.32	0.13	0.28	
4	37.5	62.5	—	—	3.9	0.302	0.14	Nil.		
	,,	,,	—	—	11.4	0.92	0.48	0.19	0.28	
5	70.6	29.4	—	—	3.9	0.33	0.13	Nil.		

Table I—(*Contd.*)

Expt.	MIXTURE.				Diameter of Seedling mm.	Thickness of Cortex. mm.	Thickness of Sclerenchyma ring. mm.	Penetration.		Remarks.
	Asphalt DX per cent.	Kerosene per cent.	Brunolinum per cent.	Dougalite per cent.				Average. mm.	Greatest. mm.	
	70.6	29.4	—	—	12.0	1.1	0.56	Very slight and only in odd places.		
6	52.2	21.7	26.1	—	3.9	0.26	0.10	Nil.		
	,,	,,	,,	—	11.0	0.87	0.43	0.17	0.21	
7	52.2	21.7	—	26.1	3.7	0.27	0.13	0.05	0.09	
	,,	,,	—	,,	11.6	0.62	0.28	0.14	0.15	
8	50	—	—	50	3.5	0.31	0.12	0.05	0.08	
	,,	—	—	—	11.0	0.61	0.28	0.15	0.22	
9	54.5	—	—	45.5	4.0	0.31	0.15	0.06	0.07	
	,,	—	—	—	10.1	0.77	0.35	0.15	0.22	
10	61.5	—	—	38.5	3.6	0.28	0.13	Nil. The mixture merely covers the cuticle.		
	,,	—	—	—	7.7	0.59	0.26	0.20	0.23	

Table I—(*Contd.*)

Expt.	MIXTURE.				Diameter of Seedling mm.	Thickness of Cortex. mm.	Thickness Sclerenchyma ring. mm.	Penetration.		Remarks.
	Asphalt DX per cent.	Kerosene per cent.	Brunolinum per cent.	Dougalite per cent.				Average. mm.	Greatest. mm.	
11	50	—	50	—	—	3.0	1.5	0.89	1.01	In Experiments 11—15 the mixture was applied to young plants about 2 years old at about 5 inches intervals from ground level towards the green parts.
						1.9	1.4	0.74	0.87	
						1.8	1.1	0.69	0.80	
						2.0	0.87	0.42	0.54	
						1.5	0.80	0.38	0.54	
						1.1	0.48	0.29	0.35	
						1.3	0.48	0.24	0.28	
						1.1	0.47	0.23	0.28	
						1.4	0.53	0.30	0.35	
						1.4	0.52	0.28	0.32	

Table I—(*Contd.*)

Expt.	MIXTURE.				Diameter of Seedling mm.	Thickness of Cortex. mm.	Thickness of Sclerenchyma ring. mm.	Penetration.		Remarks.
	Asphalt DX per cent.	Kerosene per cent.	Brunolinum per cent.	Dougalite per cent.				Average. mm.	Greatest. mm.	
12	50	—	—	50	—	3.4	1.1	0.80	1.1	
						2.6	1.1	0.78	1.0	
						1.9	0.78	0.52	0.63	
						1.6	0.74	0.44	0.54	Penetration only down to cork cambium forming a very even line, only in odd places is the penetration down to the sclerenchyma ring, but even here only a small area of cortical cells are involved.
						1.2	0.76	0.38	0.47	
						1.3	0.54	0.27	0.33	
						1.3	0.56	0.30	0.40	
						1.2	0.54	0.27	0.34	
						1.7	0.43	0.19	0.24	
	Asphaltic cement					1.2	0.41	0.19	0.22	
13	50	50	—	—	—	3.12	1.13	0.42	0.52	

Table I—(*Contd.*)

Expt.	MIXTURE.				Diameter of Seedling mm.	Thickness of Cortex. mm.	Thickness Sclerenchyma ring. mm.	Penetration.		Remarks.
	Asphalt DX per cent.	Kerosene per cent.	Brunolinum per cent.	Dougalite per cent.				Average. mm.	Greatest. mm.	
	Asphaltic cement									
13	50	50	—	—	—	2.12	0.69	0.24	0.28	
						1.74	0.64	0.24	0.29	
						1.61	0.52	0.22	0.28	
						1.34	0.46	0.20	0.25	
						1.21	0.40	0.18	0.22	
						1.21	0.43	0.15	0.24	
						1.07	0.25	0.15	0.22	
						1.1	0.40	0.17	0.24	
						1.1	0.37	0.13	0.22	
						1.0	0.35	0.14	0.15	
						1.1	0.35	0.12	0.14	

Table I—(*Contd.*)

Expt.	MIXTURE.				Diameter of Seedling. mm.	Thickness of Cortex. mm.	Thickness of Sclerenchyma ring. mm.	Penetration.		Remarks.
	Asphalt DX per cent.	Kerosene per cent.	Brunolinum per cent.	Dougalite per cent.				Average. mm.	Greatest. mm.	
14	Asphaltic cement 50	Crude Creosote. 50	—	—	—	2.6	1.1	0.29	0.54	
						2.4	1.1	0.51	0.67	
						2.0	0.87	0.25	0.40	
						1.6	0.57	0.27	0.34	
						1.4	0.44	0.22	0.34	
						1.21	0.37	0.13	0.21	
						1.2	0.34	0.13	0.14	
						1.1	0.37	0.13	0.17	
						1.1	0.46	0.19	0.29	

Table I—(*Contd.*)

Expt.	MIXTURE.				Diameter of Seedling mm.	Thickness of Cortex. mm.	Thickness of Sclerenchyma ring. mm.	Penetration.		Remarks.
	Road Asphalt per cent.	Kerosene per cent.	Brunolinum per cent.	Dougalite per cent.				Average. mm.	Greatest. mm.	
15	50	50	—	—	—	4.4	2.5	1.9	2.0	
						4.0	2.4	1.7	1.9	
						3.1	1.5	0.94	1.1	
						2.8	1.5	0.80	1.3	The covering is soft and elastic and in some cases it had not completely dried after 7 days
						2.2	0.52	0.21	0.21	
						2.0	0.45	0.26	0.39	
						1.5	0.56	0.20	0.28	
						1.4	0.41	0.15	0.17	
						0.77	0.31	No penetration beyond this point. The mixture forms a layer only on the surface of the cuticle.		
						0.78	0.32			
						0.67	0.22			

Table of Costs (June, 1930)

A.P.C. Asphalt (Grade DX)	$75.00 per ton
	=3.3 cents per lb.
S.O.C.O.N.Y. Asphaltic Cement C.C.	$72.00 per ton
	=3.2 cents per lb.
Dougalite	$ 7.50 per 5 gallon drum
	=$ 1.50 per gallon
Brunolinum (ordinary)	$ 8.00 per 5 gallon drum
	=$ 1.60 per gallon
Cross Brand Kerosene Oil	$ 2.49 per 4 gallon tin
	=62.2 cents per gallon
Singapore Tar	$19.00 per barrel (40 gal)
	=47.5 cents per gallon
Solar Oil	$16.50 per 65 gallon drum
	=25.4 cents per gallon

Specific gravity of Asphalt 1.13

Other uses. The two following mixtures have been used with satisfactory results on estates for treating the wounds after branch pruning.

1.	Asphalt (grade DX)	50 lbs.
	Kerosene Oil	4 gallons
	Cost=	49.4 cents per gallon
2.	Asphalt (grade DX)	50 lbs.
	Kerosene Oil	4 gallons
	Dougalite Cost=	60.1 cents per gallon

One estate manager states that he found the following very suitable for treating cases of " Pink Disease "

Asphalt (grade DX)	40 lbs.
Kerosene Oil	3 gallons
Brunolinum	40 ounces
Cost=	53.1 cents per gallon

Later he found that the following mixture was equally suitable, besides having the advantage of being cheaper.

Asphalt (grade DX)	40 lbs.
Solar Oil	4 gallons
Brunolinum	40 ounces
Cost=	35.4 cents per gallon

For the treatment of budded stocks after cutting back the following mixture is recommended.

Asphalt (Grade DX)	20 lbs.
Kerosene Oil	1 gallon
Cost=	46.7 cents per gallon

Only a smear of this mixture applied with the thumb is necessary for covering and sealing the cut ends of the stocks.

Summary.

The results of these experiments show that mixtures of asphalt or bitumen with kerosene or various proprietary fungicides are suitable for wound treatment, and in pruning operations on the rubber tree. The penetration of the mixtures even with young tissue is very low, so that the mixtures are not likely to cause the damage sometimes produced by tars.

REFERENCE.

1. Bituminous Substances by Percy Edwin Spielmann, Ernest Benn Ltd., London.

THE LIPIN OF HEVEA LATEX.

BY

E. Rhodes & R. O. Bishop.

Introduction.

The so-called " resins " of plantation Para rubber have been described by Whitby (8, 9 & 10) and Dekker (1) but the isolation of fatty bodies from Hevea latex itself has received little attention.

From the physiological as well as the chemical and technological points of view it is extremely important that our knowledge of these bodies be extended because, apart from a possible rôle in coagulation phenomena and possible effects on the inner properties of prepared rubber, our knowledge of the part played by phloem tissues and phloem secretions in the economy of the plant is very scanty; although latex is the secretion of a very specialized phloem tissue, it offers almost unique facilities for chemical examination and in the following pages a brief general account is given of a peculiar fatty constituent of Hevea latex. Belgrave and Bishop in their work on the serum products obtained by alcohol coagulation, separated a waxy body in quantities too small to permit of detailed examination. The present work, initiated as a result of those observations records the first steps which have been taken towards a better understanding of the nature of this substance. The investigations are a natural continuation of the series of latex studies carried out during and since 1923, and recorded in the Malayan Agricultural Journal.

Method of Preparation.

Preparations are made daily as follows:—

Latex is slowly poured into approximately 2½ times its volume of rectified spirit. The rubber is removed and pressed and the remaining alcoholic serum quickly filtered through a coarse filter paper. The fresh filtrate is quite clear but soon becomes opalescent on standing. The serum is then concentrated under reduced pressure at a temperature of 40°C. Higher temperatures cause a very pronounced darkening in the colour of the liquid. When the liquid has been concentrated to approximately one twelfth of its original volume, distillation is suspended. The aqueous liquid now possesses a milky appearance and after cooling is extracted with ether in a separating funnel. With the first fifty-two preparations it was not possible to carry out the ether extractions immediately and the milky liquids were preserved for five or six days at a temperature not exceeding 10°C.

Under these conditions the milkiness of the liquid disappears and a sweet smelling buttery substance rises to the surface. Ether extraction removes the opalescence or the scum, as the case may be, leaving a small amount of flocculent solid matter suspended in an otherwise clear liquid. Three extractions with ether usually suffice to remove the ether soluble material but it is necessary to exercise care to avoid the formation of emulsions which are very slow in breaking. The combined ether extracts containing the fatty constituent are evaporated quickly to dryness at room temperature and finally dried in a vacuum desiccator. The product is a solid, transparent, golden yellow body with a rather waxy feel and an earthy taste. Small quantities of the substance are prepared daily and when a suitable number of small preparations has accumulated, they are redissolved in ether and bulked. The ether is removed and the resulting bulk is dried in a vacuum desiccator and weighed. It is thus possible to obtain an idea as to the amount of substance obtainable by this means from a given quantity of latex. In Table I the figures are given for the first four bulked samples. The latex used in these experiments was obtained from the same block of trees situated at the Department of Agriculture, Kuala Lumpur.

TABLE I.

Sample No.	No. of samples bulked.	Daily samples prepared in 1930 between	Total Volume of latex employed. cc.	Total Wt. of ether soluble product. gm.	Wt. of product per 100 cc. latex gm.
I	15	May 29th & June 30th	19,700	45.7	0.232
II	11	July 1st & July 17th	15,300	36.0	0.235
III	11	July 18th & Aug. 1st	16,200	34.4	0.212
IV	15	Aug. 5th & Aug. 26th	21,600	35.6	0.165
Totals.	52	May 29th & Aug. 26th	72,800	151.7	0.208

It will be observed that the yield is approximately 0.2 per cent calculated on the latex. This figure is much lower than the values obtained by Dekker (1) by hot acetone extraction of smoked sheet which were 4 per cent on the dry rubber, representing approximately 1.4 per cent on the original latex. The method of cold extraction in an alcohol-water mixture adopted in our experiments could not possibly result in an exhaustive removal of the so-called

" resins " and can only be expected to remove such bodies as are very readily dispersible in water or alcohol and which are more of the nature of lipins than true fats or fatty acids.

General Physico-Chemical Properties.

The substance obtained is very readily dispersible in water. When an ether solution is rubbed in a mortar with distilled water and the ether removed, there remains a permanent milky suspension with a slightly yellow tinge. The suspension resembles a soap solution forming foams and bubbles on agitation. From such a suspension it is practically impossible to re-extract the substance with ether. In one experiment the attempt was made to wash the substance with water to free it from possible inorganic impurities. It was suspended with water in a separating funnel and ether was added. Even very slight agitation caused the dispersal of the ether into the aqueous medium from which it could not be induced to separate. Even after fourteen days the separation was only just commencing.

When a small quantity of the solid is treated with a drop or two of water and left for some hours the material assumes the form of a jelly. If the early stages are observed under the microscope small round globules can be seen detaching themselves from the main mass floating away into the water. Myelin forms do not appear to occur.

The substance has a pronounced effect on surface tension. An emulsion in distilled water was prepared, having a concentration of 0.2 per cent. which imitates what appears to be its concentration in latex. The surface tension measured by a Du Nuoy ring testing apparatus was approximately half that of distilled water. Stronger suspensions produced greater reductions in surface tension.

The substance can be flocculated from a water emulsion by the addition of acids. A 2 per cent suspension in distilled water had a pH value of 5.8 as measured by the quinhydrone electrode. The addition of a small quantity of mineral acid produced a distinct colour change, the emulsion becoming distinctly whiter in colour but with no pronounced change in stability. With the addition of increasing quantities of acid the colour became progressively whiter and when a pH value of 2.5 was reached there were distinct signs of the formation of curds. At a pH value of 1.9—2.0 the suspended material was precipitated in large curds in a water clear liquid. The curds were still soluble in ether and extraction was quite easy. The tendency to form emulsions seemed to have largely disappeared. The apparently complete flocculation can be brought about with any of the strong mineral acids and with formic acid but not with acetic acid.

In a similar manner an apparently complete flocculation is produced by the addition of a little calcium chloride or magnesium chloride and in both cases the flocculated material is soluble in ether.

General Chemical Properties.

The substance has no definite melting point. When heated to 60°C. it softens slightly but does not melt. When heated over a free flame it melts and chars at the same time, giving off first a smell like hot lard and finally cokes badly, smelling like burnt sugar.

When a little of the dry material is treated with concentrated nitric acid there is a very striking colour change. The mass immediately assumes a bright cherry red colour. The solid matter breaks up and the acid liquid assumes the red colour. On standing for some little time a dark red oil comes to the surface leaving a clear liquid below. If the liquid is heated, nitrous oxide is evolved, and the red oil disappears to be replaced by yellow oil drops which solidify to form a bright yellow waxy body, soluble in ether and warm alcohol.

In common with the cerebrosides it gives a deep purple red colour when rubbed with concentrated sulphuric acid and this colour is produced very quickly in presence of a little cane sugar.

The substance gives a strong Molisch reaction. Protein tests are negative.

The Iodine number of the original material is 97. If an aqueous suspension be made, flocculated with acid and the precipitated material extracted with ether, it is found that approximately 95 per cent. of the original weight of material has been recovered. The loss in weight is due in the main to the loss of inorganic constituents. The Iodine value of the ether extracted material is now found to be 102, and the increase from 97 corresponds to the loss of 5 per cent. of material having no iodine value.

Ether Soluble Phosphorus and Nitrogen.

The various bulk preparations all contain nitrogen and ether soluble phosphorus and all have a fairly high ash content. The precise amounts of each in the different bulked samples are very similar. Table II gives the values obtained. Nitrogen was estimated by the Kjeldahl method and phosphorus by Neumann's gravimetric method as magnesium pyrophosphate.

TABLE II.

Bulk.	N. per cent.	P. per cent.	Ash per cent.	N/P ratio.
I	0.59	1.72	5.35	1 : 1.32
II	0.58	1.67	5.74	1 : 1.30
III	0.55	1.45	5.49	1 : 1.19
IV	0.54	1.59	4.60	1 : 1.33

These figures, while suggestive of the presence of lipins, indicate that if such be present they are not by any means in a state so pure as is

attained with animal phosphatides, since, for a pure phosphatide such as lecithin, the nitrogen and phosphorus contents would be approximately 1.8 and 4.0 respectively, while a pure cerebroside would similarly require 1.8 per cent. of nitrogen and no phosphorus.

It is customary to calculate the amount of phosphatide from the formula—Lecithin (per cent.) = P_2O_5 (per cent.) × 11.37—so that the substance of Sample I should contain $\frac{1.72 \times 142 \times 11.37}{62} = 44.8$ per cent. of phosphatide. Now since the phosphatides are insoluble in acetone, some 44.8 per cent. of the bulk of the fat should be insoluble in acetone but soluble in ether. A known weight of dry substance (6.40gm) was extracted with six successive lots of warm acetone. The residual insoluble material was treated with ether. It gave a solution which was very slightly opalescent. This on filtration became quite clear and the final yield of acetone-insoluble, ether-soluble material was 2.666 gms. that is 41.7 per cent. of the whole. This material when subjected to analysis gave the following figures:—

N	P	N/P
per cent.	per cent.	ratio.
0.88	2.56	1:1.31

These figures indicate that this fraction although present in the expected amount does not consist at any rate of a pure phosphatide although the amounts of ether-soluble phosphorus and nitrogen show a decided increase and retain the same mutual ratio.

Fat Constants.

The original substance has an acid value of 14, and an ester value of 159, giving a true saponification value of 173. The quantity of unsaponifiables soluble in ether is 1.1 per cent. and the yield of ether soluble acids is 71 per cent. of the original weight of material. Now a true fat would give a much higher saponification value even if its constituent acids were of high molecular weight and a yield of acids in the region of 90 per cent. A wax would give a low saponification value but a high unsaponifiable content. The low value obtained for unsaponifiable matter excludes a high content of wax. A true phosphatide yields 70 per cent. of its weight of fatty acids but it has been shown that the substance is not a pure phosphatide of the lecithin type. The figures thus indicate the presence of some substance which is not normally a constituent of fats, waxes or of pure animal phosphatides.

Fatty Acids.

When the mixed acids obtained by alkaline hydrolysis were subjected to separation by the lead salt-ether process into their solid

and liquid constituents it was found that liquid acids constituted practically the whole. The amount of solid acids was 5 per cent., the remaining 95 per cent. falling into the category of liquid acids. Determinations of the Iodine values of the two fractions showed that, as is often the case, separation had not been perfect. The values were

Liquid acids	...	123
Solid acids	...	59

The solid acids were quite white and hard. The liquid acids when brominated in the usual manner for the determination of the hexabromide value, yielded a little ether insoluble bromide (1.924 gms liquid acids gave 0.043 ether insoluble bromide) which calculated as a percentage on the weight of acids gives a value of 2.5 per cent. for possible hexa and octabromides. When the ether soluble bromides were submitted to semi-quantitative separation by petrol ether into soluble and insoluble fractions, the presence of a large proportion of acids belonging to the linoleic series was indicated. Dekker (1) isolated from smoked sheet liquid acids having an iodine number of 131 which is in agreement with the figure obtained in our experiments.

In order to test whether resin acids proper, as distinct from fatty acids, were present in the mixed acids, a known quantity of mixed acids were subjected to alcoholysis by Twitchell's method. The acids in solution in absolute alcohol were treated with hydrochloric acid gas until saturated. By this means the fatty acids but not the resin acids would be esterified. After cooling, and dilution with water, the liquid esters and resin acids were extracted with ether, the ether solution washed until free from acid and diluted with alcohol. Titration with standard alkali gives a measure of resin acids. The mixed acids were found to be 97 per cent. esterifiable and since this method always gives high results for resin acids, it may be taken that resin acids proper are present only in negligible quantity and that the mixed acids consist of true fatty acids.

Sugar, Possible Bases and Glycerol.

Using a small quantity—about 4 gms—of the material, an attempt was made to obtain by alcoholysis a solution containing any bases in a condition suitable for the application of qualitative tests. The crude material was treated with absolute alcohol in which it was not however completely soluble, and dry hydrochloric acid gas was passed through the liquid until saturation was reached. By this time the liquid was very dark brown in colour. The flask was heated under a reflux condenser on the water bath for five hours. As heating proceeded, the liquid became quite black and humus bodies began to be formed. After removing alcohol and adding water, the esters appeared as a dark oil on the surface of the acid aqueous liquid. Esters were removed by extraction with ether and humus bodies by

filtration. The aqueous liquid was made up to a known volume and parts of it were used for various tests. The appearance of humus bodies, in the known absence of proteins, had already given the clue that hexose sugars must be present in the original material and undergoing decomposition by heating in the strongly acid solution. The aqueous liquid reduced Fehling's solution very readily and gave a crystalline osazone which when examined under the microscope was found to consist of small somewhat irregular shapes such as are given by galactose and sometimes maltose. It is not yet possible definitely to name the sugar but its existence in every sample since treated has been ascertained by the osazone reaction. When an aliquot part of the aqueous solution was estimated for sugar by the reduction of Fehling's solution and the value for hexose calculated on the original weight of material a figure of 12 per cent. was obtained, but little reliance can be placed upon it in view of the very drastic decomposition which had taken place with the probable appearance of reducing bodies other than sugar. The development of humus bodies should coincide with the appearance of levulinic acid. The aqueous liquid was found to contain a body which readily gave the iodoform reaction in the cold which is one of the characteristics of levulinic acid. The usual precipitants for bases, mercuric chloride, platinum chloride and picric acid, applied in alcohol solution, and phosphotungstic acid all give precipitates readily and the Florence test with KI_3 was positive. The material precipitated by phosphotungstic acid, when analysed for nitrogen and referred to the original weight of fat indicated that 71 per cent. of the total nitrogen had been so precipitated. The evidence thus indicates the presence of a base of which the nature is as yet unknown.

A part of the liquid was treated with freshly prepared bromine water to oxidise any glycerol to dihydroxy-acetone which when dehydrated to methylglyoxal by sulphuric acid gives colour reactions with alcoholic solutions of (a) salicylic acid and potassium bromide, (b) resorcinol (c) thymol and (d) β naphthol. These tests were positive. The acrolein test was applied to a little of the original material. The actual smell of acrolein was masked by that of burnt sugar but the vapours were strongly irritating to the eyes and throat indicating the probable presence of acrolein. The evidence so far obtained thus favours the presence of glycerol, but it will be necessary to work with larger quantities of material before its presence or absence can be definitely proved and its amount estimated.

The Occurrence of the Sugar.

In the first hydrolysis of the material by alcoholic potash a sticky substance was observed to be precipitated during saponification. Later, when the alcohol was removed and water was added for the purpose of extracting unsaponifiable matter this body dissolved quite

readily and did not interfere in any way with subsequent treatments. The aqueous liquids after removal of unsaponifiable matter and fatty acids were neutralized before evaporating to small bulk for examination. These liquids were tested for the presence of reducing substances but always failed to reduce Fehling's solution. After having definitely noted the presence of reducing sugar in the products of acid hydrolysis, further samples of material were submitted to alkaline hydrolysis and the sticky material which was precipitated during saponification was separated from the alcoholic liquid by decantation. After washing with absolute alcohol, and combining the washings with the original alcoholic potash, the alcohol insoluble body was made up to a known volume with water, in which it readily dissolved. This solution was found to contain 98 per cent. of the total phosphorus present. This might have been predicted since the alkali phosphates are practically insoluble in alcohol. The aqueous liquid did not reduce Fehling's solution. It was found however that if the solution were heated with 10 per cent. of hydrochloric acid for some little time and then neutralized, it reduced Fehling's solution readily and gave an osazone exactly similar to that previously obtained by acid hydrolysis. The amount of hexose was 8 per cent. of the whole, when estimated by the reduction of Fehling's solution and calculated as a percentage of the amount of the fatty body. The saponification liquid after removal of alcohol, addition of water, precipitation and removal of fatty acids, smelt strongly of sugar, and after inversion with hydrochloric acid, itself reduced Fehling's solution. The amount of hexose present in this liquid was 1.6 per cent. which would give a total of 9.6 per cent. for the total hexose present. This value is lower than that obtained previously but it has since been shown that the whole of the sugar is only split off with some difficulty. Further it would appear that the sugar is not present originally as a reducing sugar. In a subsequent experiment, a known weight of the body was dispersed in water and treated with 10 per cent. of hydrochloric acid. It flocculated immediately and the suspension was heated to boiling over a free flame, until a stage was reached when the curds appeared quickly to reduce in volume and rise to the surface. Heating was then stopped and after removal of the suspended matter with ether, the acid liquid was found to contain an amount of hexose equivalent to only 3.6 per cent of the original weight of material. It has since been found that in such an acid hydrolysis in an aqueous medium, if heating be continued after the stage when the curds appear to change in consistency, they eventually undergo a further change and form a definite oily layer at the surface, and the reducing power of the liquid is now very much greater.

In another experiment, a quantity of the material was dissolved in ether, poured into distilled water and warmed on the water bath at 70°C. to remove the ether, leaving a uniform dispersion. This was

flocculated by the addition of excess dilute hydrochloric acid and the flocculated matter extracted with ether. The aqueous liquid was preserved, and the ethereal solution which would contain a little acid, poured into a fresh lot of distilled water. The ether was again removed by heating on the water bath leaving a very white dispersion from which a little solid matter settled out after some hours. The suspended matter was again removed with ether and re-emulsified on the water bath as before. The suspension this time behaved like a thick flour paste, but dilution with water after some hours standing showed the presence of innumerable small flocks. The extraction and redispersion was carried out five times, the emulsion being allowed to stand for some hours in each case before being extracted with ether. At the fifth attempt no smooth dispersion was possible. The material was still not oily, but it consisted of flocks large enough to be incapable of dispersion. Examination of the aqueous liquids remaining at each stage showed that at the first flocculation the material lost a large proportion of its ash constituents. Subsequently a little more was lost at each stage. Sugar was similarly lost at each stage together with some phosphorus and nitrogen. It is notable that the amount of phosphorus lost at the first flocculation is much smaller than in succeeding ones. The material remaining when dispersion had become impossible still contained an appreciable amount of phosphorus and nitrogen but practically no ash. The total loss in reducing sugar estimated at each stage amounted to 10 per cent. of the original weight of the material. There is a decided loss in freedom of dispersion after the first flocculation when the greater part of the ash constituents are removed. Subsequently the decrease appears to be gradual with the loss of sugar at each stage.

Discussion.

Sufficient evidence has been obtained to show that the material under examination is a peculiar complex of fatty acids, sugar, ether soluble phosphorus and nitrogen, and possessed of properties abnormal to fatty bodies other than the ill defined class called Lipins. It is of considerable interest to compare some of the available facts with those adduced by other workers in the field of plant lipins. Maclean (2) has observed that the difficulties of investigating plant lipins are much greater than with similar products from animal organs and that the difficulties are chiefly due to the presence of large amounts of carbohydrate material tending to form physical complexes similar to the "jecorin" bodies found in the animal world. Schulze & Winterstein (7) pointed out that plant phosphatides contain considerably less phosphorus and nitrogen than the theoretical amount for lecithin. Winterstein & Hiestand (11) showed that plant phosphatides yield on hydrolysis sugar as well as the usual decomposition

products of phosphatides. The sugar content could be as high as 16 per cent. Specimens yielding large amounts of sugar generally yielded low phosphorus values. The sugars present can be in part removed by repeated washing with water but various authors have produced evidence that some of the sugar is in chemical combination since long boiling with acid is necessary to remove it. Maclean (2) says " there is no evidence that any observer has succeeded in obtaining from plants a carbohydrate-free lecithin similar to the body found in animal tissues and organs." Amongst the " jecorin " bodies of the animal world, some have been found which do not reduce Fehling's solution directly. Offer (4) and others have supplied such evidence, and Manasse (3) and Sakaki (5 & 6) describe jecorins which only reduce after long boiling with acid. The evidence provided by previous workers in the field of plant lipins provides a striking parallel to the present work and leaves little doubt that the material from Hevea latex, while no more a pure phosphatide than any plant lipin previously described, can by virtue of its behaviour and chemical composition be described as a plant lipin.

It is interesting also to note that by expressing the observed amount of phosphorus as glycerophosphoric acid, the nitrogen as choline, and ash as potassium oxide, a very interesting summation of constituents can be made.

		Per cent.
Phosphorus found, expressed as glycerophosphoric acid $1.72 \times \frac{172}{31}$	=	9.55
Nitrogen found, expressed as choline $0.59 \times \frac{129}{14}$	=	5.06
Unsaponifiable matter found	=	1.10
Fatty acids found	=	71.00
Sugar found	=	10.00
Ash expressed as K_2O (found 5.35% ash)	=	3.55
		100.26

It may be argued that the calculations for nitrogen and phosphorus are not strictly justified, but since each of the elements must occur in some form of combination, it is at any rate reasonable to employ calculations for which there is some basis of evidence and it is of interest to find that by such means it is possible to account for the whole of the material. Such a conception of its composition would allow for the presence of free fatty acids, some fatty acid soap as well as for fatty acids united to sugars, all of which seem necessary to explain the behaviour of this peculiar complex.

With the accumulation of larger quantities of material it is hoped to isolate the various constituents in reasonably large amounts and

definitely to establish the identity of those about which some uncertainty at present exists.

SUMMARY.

A body having properties and composition similar to those of the plant lipin complexes described by various authors, has been isolated from Hevea latex.

ACKNOWLEDGMENT.

The authors' thanks are due to Major B. J. Eaton for his interest and encouragement in the progress of the investigations, and to Mr. K. C. Sekar for his assistance in many of the operations involved.

NOTE.

Since writing the above we have received Van Harpen's (8) recent publication dealing with the flocculation and coagulation of Hevea latex. In this publication some doubt is cast upon the validity of the theory of Belgrave because the lecitho-sugar complex which he postulated in 1923 had not up to the present been isolated. Since the phosphatide-sugar complex has now been isolated from fresh latex it becomes obvious that the theory originated by Belgrave assumes new and added significance.

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OBSERVATIONS ON THE EFFECT ON VULCANISATION OF THE LIPIN OF HEVEA LATEX.

BY

B. J. Eaton, E. Rhodes & R. O. Bishop.

Some preliminary vulcanisation tests which have been made with the Hevea lipin (vide this journal p. 125) are described.

As already shown by one of the authors (1) the rubber derived from alcohol coagulated latex exhibits a much faster rate of cure than crepe prepared by the orthodox method of acid coagulation. In the present investigation it has been found that the alcohol coagula on pressing and drying give a rubber which shows an optimum cure at 60 mins. compared with 90 mins. for plantation crepe vulcanised under the same standard conditions in a mix consisting of 100 parts of rubber plus 10 parts of sulphur cured in a steam autoclave at 148°C. It is thus somewhat slower in rate of vulcanisation than " slab " rubber and approximately equivalent to " Fine Hard Para."

It has been found that the rate of vulcanisation of this alcohol coagulated rubber prepared from different days' crops of latex shows practically no variation. Differences in detail of preparation, such as length of time of soaking in alcohol, dilution of alcohol, and period of drying of the coagula are insignificant.

The tensile strength and other properties of the vulcanised product are normal.

All preparations of alcohol coagulated rubber to which the separated lipin has been returned show a definite acceleration in cure. An addition of 1 per cent. of lipin is proportionately more effective than 2 per cent., and 2 per cent. is proportionately more effective than 3 per cent., but there is acceleration in all cases which is of the same order as that exhibited when the lipin is added to slab rubber (Fig. III).

When the separated lipin is added to simple mixes containing only sulphur and normal plantation rubber its effect varies according to the rate of cure of the rubber. With fine pale crepe, which under our standard condition of vulcanisation has an optimum cure of 100 minutes, the addition of Hevea lipin in the proportion of 1 per cent. on the rubber causes no appreciable acceleration while the addition of 2 per cent. accelerates by 10 minutes (Fig II).

By contrast if 1 per cent. of the Hevea lipin is added to normal "slab" crepe, which under our standard conditions has an optimum cure of 40 minutes, an acceleration of 10 minutes is produced. (Fig. III).

Mixes containing 5 parts of zinc oxide per 100 parts of rubber show a greater acceleration for the addition of 1 per cent. lipin than corresponding rubber-sulphur mixes with and without zinc oxide, and in normal plantation crepe the degree of acceleration is enhanced to such an extent that the optimum cure is almost as rapid as that obtained for a similar mix containing slab rubber. (Figs. IV, V, & VI).

It will be seen from a comparison of Figs. II & VI that the rate of cure for the crepe is increased so much that the cure at 20 minutes (Fig. VI) is more complete than that for 70 minutes in Fig. II.

Effect of Lecithin.

In view of the probable relationship between Hevea lipin and egg lecithin their effects on vulcanisation were compared. When crude technical lecithin was added to ordinary thin crepe rubber it was found that the degree of acceleration was materially greater than for Hevea lipin.

Effect of Hevea Lipin and Egg Lecithin on Rubber-Sulphur Mixes.

It is interesting to note, however, that the effect of adding lecithin to rubber while mixing on the hot rolls is strikingly similar to that produced by Hevea lipin. Immediately the lecithin or lipin is added, the plastic mass becomes opaque and crumbles and resembles breadcrumbs. When the crumbling mass is subjected to further mastication, although the temperature is not allowed to rise above 55°C., a further change takes place and the mass again assumes the appearance characteristic of masticated rubber on the hot rolls.

The addition of small quantities of Hevea lipin or egg lecithin to raw rubber in the form of plantation crepe, smoked sheet or slab crepe is always accompanied by the same peculiar behaviour during mastication on warm rolls. If however the rubber is first mixed with sulphur and/or zinc oxide, the degree of crumbling is considerably lessened but the partially masticated mix shows a strong tendency to adhere to the rolls in spite of the fact that the mass feels distinctly greasy.

From the similarity in the behaviour of the mixes containing egg lecithin or Hevea lipin it is evident that we are dealing with a phenomenon related in some manner to the chemical characteristics of this class of bodies.

From the preliminary work which we have carried out with the Hevea lipin, three important facts emerge:—

(a) The peculiar physical effect of the lipin on the maceration properties of raw rubber on warm rolls.

(b) The acceleration of cure caused by the lipin in fast curing rubbers,—slab and alcohol coagulated,—contrasted with the comparatively small effect on a slow curing rubber such as fine pale crepe or smoked sheet.

(c) The increased accelerating effect of the lipin in the presence of zinc oxide.

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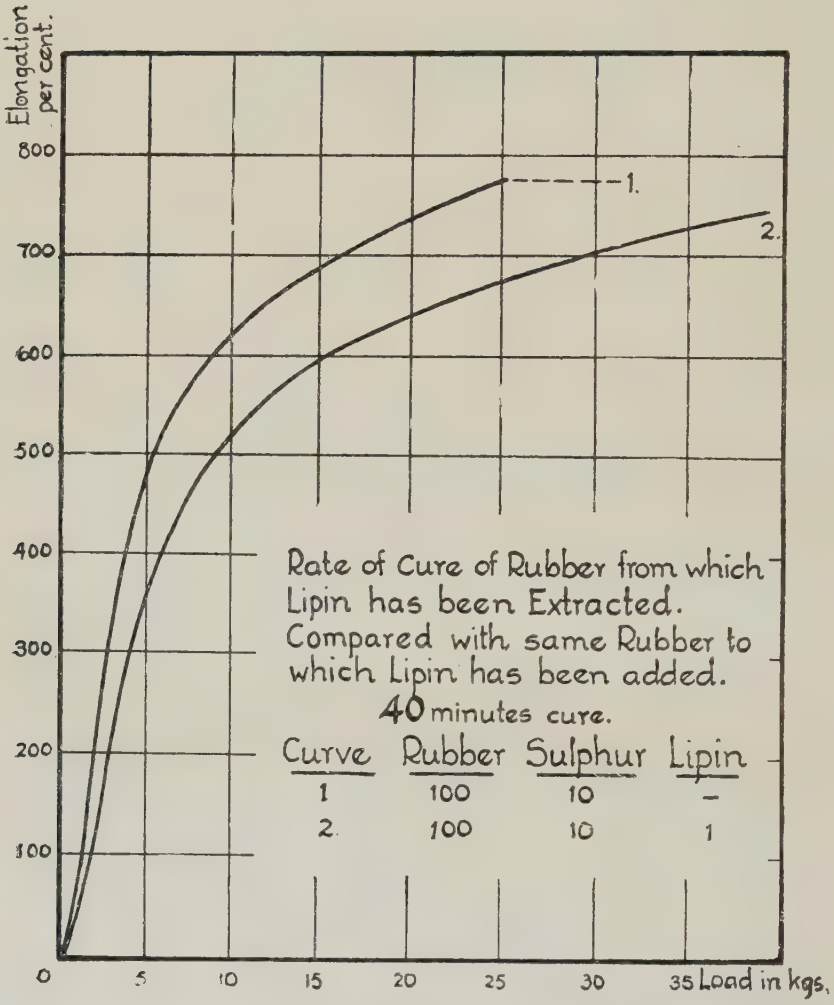
Elongation per cent.
800
700
600
500
400
300
200
100
0
5
10
15
20
25
30
35 Load in kgs.
1.
2.
Rate of Cure of Rubber from which Lipin has been Extracted.
Compared with same Rubber to which Lipin has been added.
40 minutes cure.
Curve Rubber Sulphur Lipin
1 100 10 –
2. 100 10 1

Fig: 1.

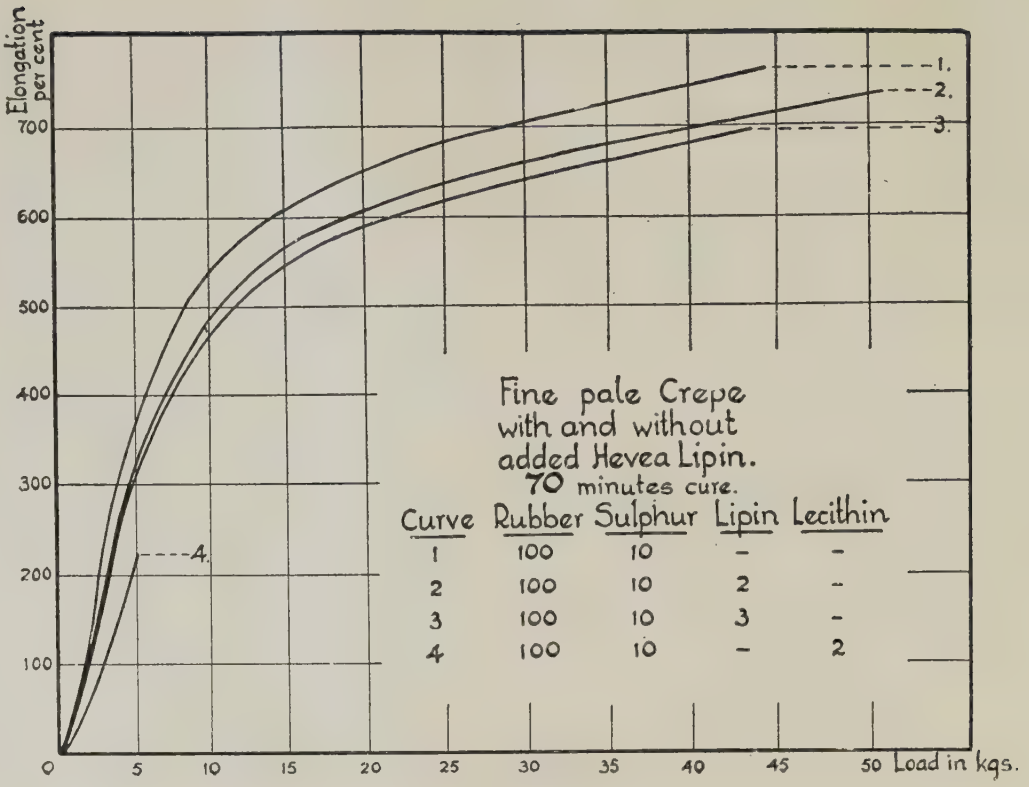
Elongation per cent
700
600
500
400
300
200
100
0
5
10
15
20
25
30
35
40
45
50
Load in kgs.
1.
2.
3.
4.
Fine pale Crepe with and without added Hevea Lipin.
70 minutes cure.
Curve Rubber Sulphur Lipin Lecithin
1 100 10 – –
2 100 10 2 –
3 100 10 3 –
4 100 10 – 2

Fig 11.

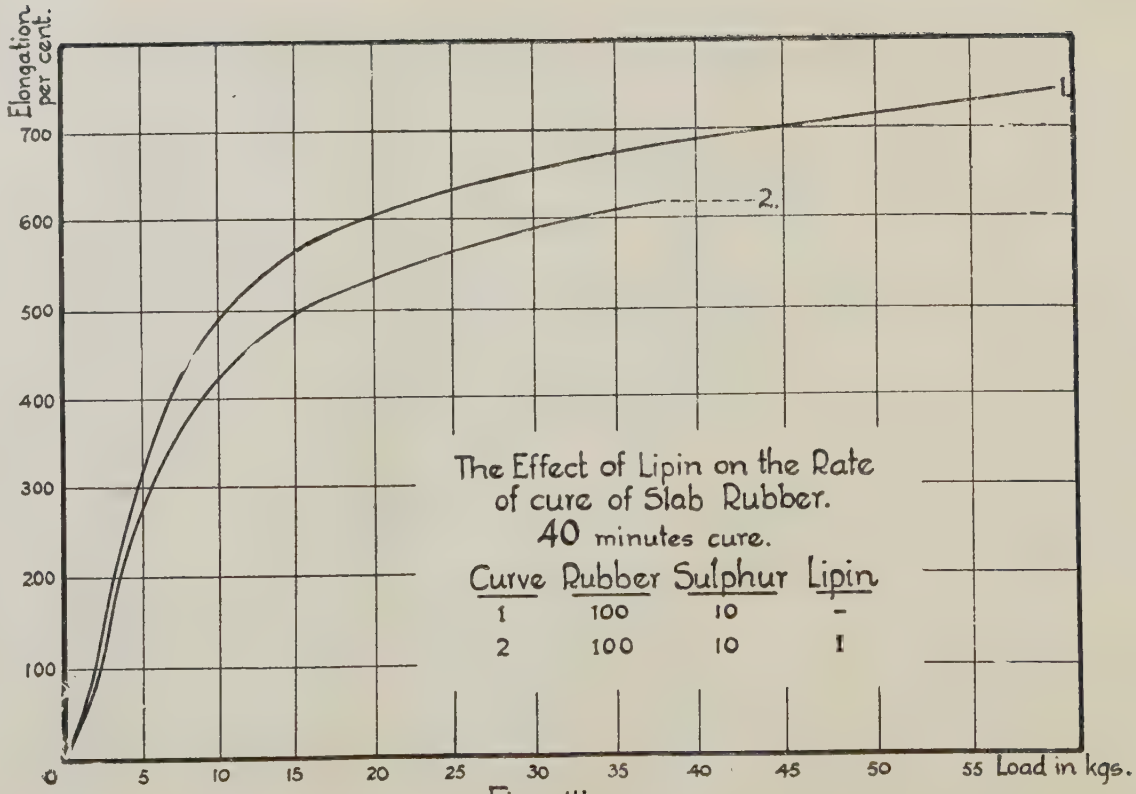
Elongation per cent.
700
600
500
400
300
200
100
0
5
10
15
20
25
30
35
40
45
50
55
Load in kgs.
1
2.
The Effect of Lipin on the Rate of cure of Slab Rubber.
40 minutes cure.
Curve Rubber Sulphur Lipin
1 100 10 –
2 100 10 1

Fig. III.

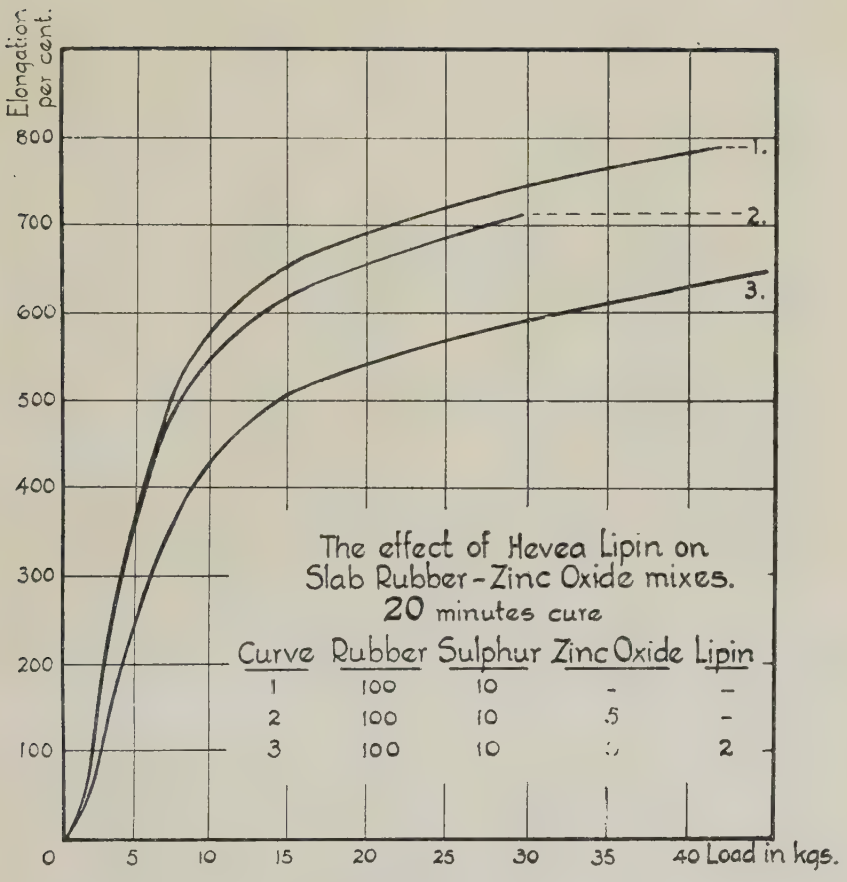
Elongation per cent.
800
700
600
500
400
300
200
100
0
5
10
15
20
25
30
35
40 Load in kgs.
1.
2.
3.
The effect of Hevea Lipin on
Slab Rubber-Zinc Oxide mixes.
20 minutes cure
Curve Rubber Sulphur Zinc Oxide Lipin
1 100 10 - -
2 100 10 5 -
3 100 10 5 2

Fig IV.

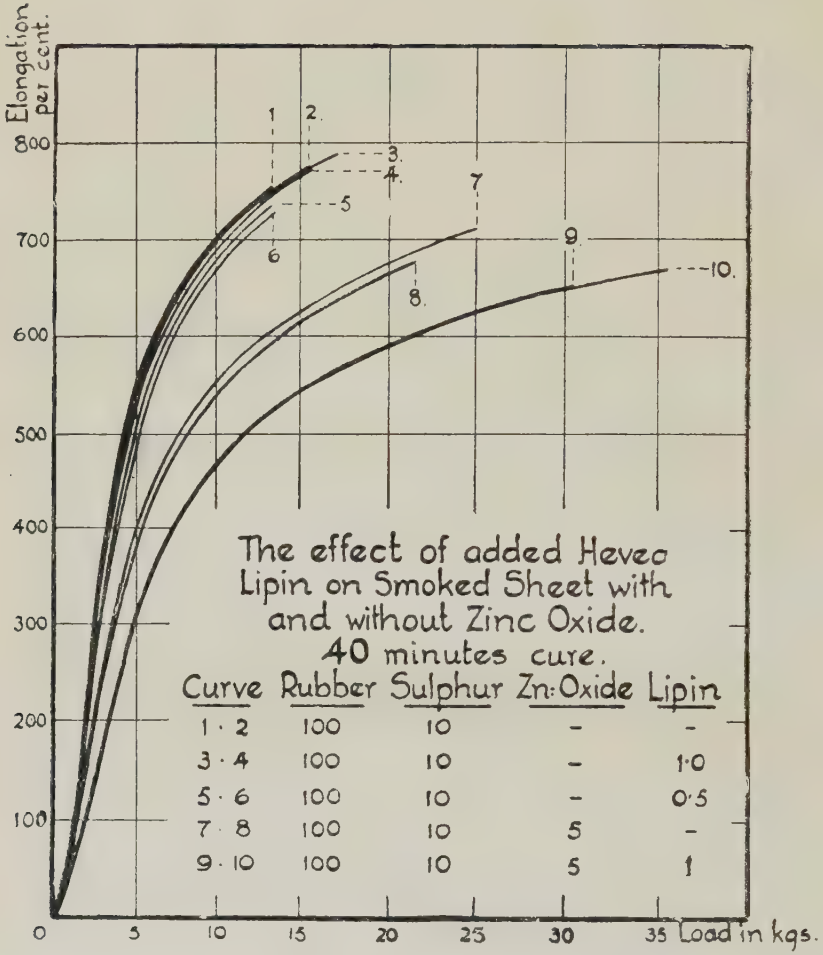
Elongation per cent.
800
700
600
500
400
300
200
100
0
5
10
15
20
25
30
35
Load in kgs.
1
2
3
4
5
6
7
8
9
10
The effect of added Hevea Lipin on Smoked Sheet with and without Zinc Oxide.
40 minutes cure.
Curve Rubber Sulphur Zn:Oxide Lipin
1 · 2 100 10 – –
3 · 4 100 10 – 1·0
5 · 6 100 10 – 0·5
7 · 8 100 10 5 –
9 · 10 100 10 5 1

Fig V.

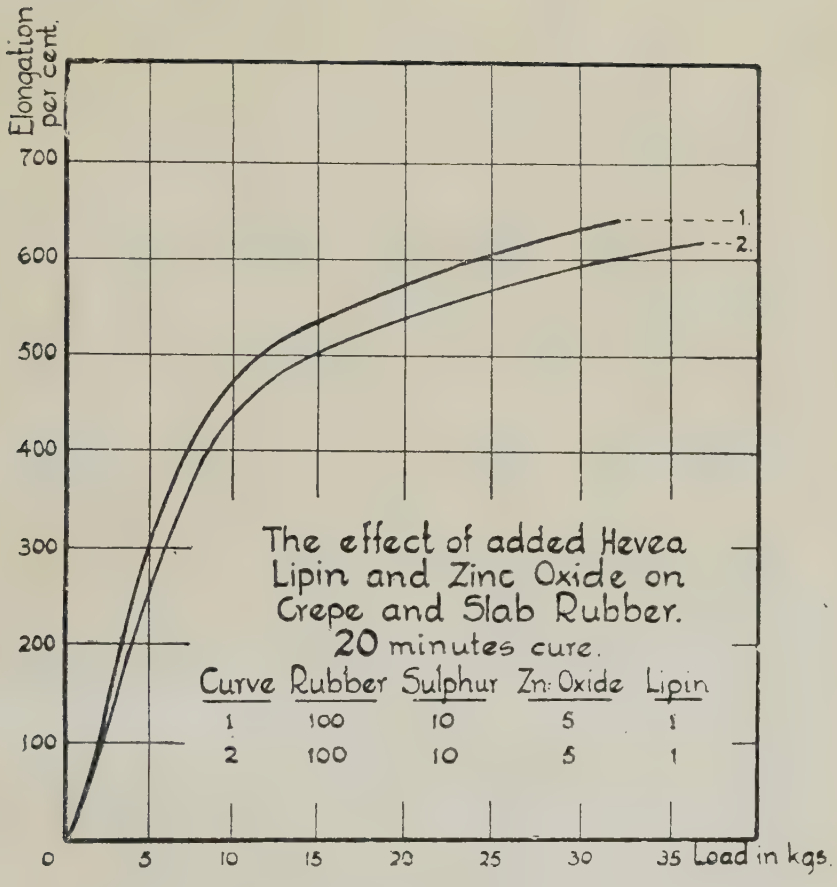
Elongation per cent.
700
600
500
400
300
200
100
0
5
10
15
20
25
30
35
Load in kgs.
1.
2.
The effect of added Hevea Lipin and Zinc Oxide on Crepe and Slab Rubber.
20 minutes cure.
Curve Rubber Sulphur Zn: Oxide Lipin
1 100 10 5 1
2 100 10 5 1

Fig: VI.

A PRELIMINARY STUDY

OF

THE BACTERIOLOGY OF HEVEA LATEX.

BY

A. S. Corbet.

Many, if not most, of the naturally occurring changes in latex are attributable to bacterial activity, and as latex is of considerable commercial importance, it is surprising that the bacteriology of latex has received hitherto very little attention. It has long been recognised that latex has a teeming bacterial population. Fifteen years ago, Eaton and Grantham (1) showed that natural coagulation was the outcome of bacterial activity. In 1917, Denier and Vernet (2) published the results of a bacteriological study of Hevea latex carried out in Annam. They gave brief descriptions of 25 species of organisms which they had isolated, and judging by their precautions to avoid contamination, it is possible that the organisms studied entered the latex at the tapping cut.

The most interesting species recorded by Denier and Vernet was "*Bacillus No. 1*" which was distinctive in that it occurred in all samples examined and in its ability to produce acid from "dambosite" (presumably methyl l-inositol). According to the authors, "*Bacillus No. 1*" produced complete coagulation within 24 hours when introduced into latex cups.

The writer (3) has already reported that *Bacillus pandora* (which is almost certainly identical with "*Bacillus No. 1*") produced acid in latex but was not able to effect complete coagulation of sterile diluted latex.

Prescott and Doetger (4) have recently published a short paper on latex bacteriology. No particulars are given concerning the source of their latex supply, and clearly the writers are dealing with a set of organisms different from those found in the latex of Annam and Malaya. Many of these organisms are strong acid producers whose activities are retarded but not destroyed by the presence of ammonia.

Although the work described in the present paper can only be regarded as a preliminary investigation of Hevea latex bacteriology, some of the results obtained throw new light on several points of interest connected with the preparation of rubber.

The new organisms described are:—

Gaffkya verneti,
Micrococcus eatoni,
Micrococcus ridleyi,
Micrococcus epimetheus,
Micrococcus chersonesia,
Alcaligenes denieri,
Torula heveae.

Of these, *M. epimetheus* is of considerable interest. Like *B. pandora*, which it resembles in many respects, it produces acid in latex and so plays a part in natural coagulation; also, of all the organisms isolated, it alone produces gas with latex products and so must be considered to be one of the causes of bubble formation in sheet rubber.

Three of the remaining organisms are of interest in that they produce a yellow pigment with latex.

M. chersonesia exhibts the phenomenon of dimorphism, occurring in two colony forms which are associated with differences in the form of the organisms.

The Natural Coagulation of Latex.

Some further information has been obtained concerning natural coagulation of Hevea latex.

It has been shown previously (3) that *Bacillus pandora*, a spore forming organism, produced acid in latex in sufficient quantity to bring about flocculation of the rubber particles. This bacillus also produced acids from the sugars, glucose, lactose and sucrose and so doubtless plays an important part when coagulation is effected by addition of sugar (1).

It has now been found that *Micrococcus epimetheus* possesses similar properties, viz. it effects both acidification and flocculation of latex, and it hydrolyses arabinose in addition to the above mentioned sugars.

M. epimetheus, however, does not form spores, so it is to be presumed that, in general, it enacts a considerably less important rôle than *B. pandora* in the phenomenon of coagulation.

Attention has already been drawn to the fact that *B. pandora* may produce coagulation as well as flocculation of the rubber particles when introduced into sterile diluted latex and similar observations have now been made with regard to *M. epimetheus*. With a view to obtaining some quantitative measure of this coagulation, several test tubes, each containing 10 c.c. of sterile diluted latex were inoculated with the organisms. After 7 weeks the clots of rubber were removed, washed, dried in an air-oven at 70° C. and weighed. The results are given in Table I.

TABLE I

Organism.	No. of Experiments.	Average weight of clot.
B. pandora	7	0.60 g.
M. epimetheus	5	0.69 g.
Both organisms	7	0.60 g.
Control	3	0.14 g.

From these figures it is clear that a certain amount of coagulation took place as a result of the presence of the bacteria. It should be observed that work of this nature must be carried out with diluted latex in such concentrations as will withstand autoclaving without coagulation. Latex so treated, however, becomes incapable of being coagulated in the first coagulation zone (5) upon addition of acid. Such experiments as the above, therefore, give no proof that acid production by *B. pandora* and *M. epimetheus* in *fresh latex* is not entirely responsible for complete coagulation.

When considering the acidification of latex by *B. pandora*, the writer, in a previous paper (3) followed former authors in assuming that the acid resulted from the decomposition of methyl l-inositol. No experimental evidence has been obtained to justify this assumption. No acid resulted from inoculation of a liquid medium containing methyl l-inositol with *B. pandora*, although abundant acidification occurred when latex serum, obtained from frozen latex, was inoculated with the bacillus.

Acid, but no gas, resulted when *M. epimetheus* was introduced into an aqueous solution of methyl l-inositol containing small amounts of magnesium hydrogen phosphate and potassium chloride, but no action was detected in the absence of the magnesium salt. Acid and gas resulted from inoculation of latex serum with this micrococcus.

Of the latex substances likely to yield acid on bacterial decomposition, methyl l-inositol alone is present in any quantity and its resistance to attack by the bacillus is surprising. It is possible that the presence of some factor or factors, as yet unknown, is necessary before this decomposition can take place, a view which receives support from the behaviour of *M. epimetheus*.

Much work remains to be carried out on the chemical constitution of Hevea latex, and a difficulty in this connection is that under normal conditions many of the organic constituents are changing continuously as a result of bacterial activity. It is hardly surprising, therefore, that our knowledge of the substances occurring in latex in small amount is rather scanty.

Bubbles in Sheet Rubber.

The presence of bubbles in sheet rubber is of frequent occurrence and has been attributed to a variety of causes. Eaton (6) considers

that most cases are due to bacterial activity, especially in the coagulating tank in presence of insufficient coagulant.

Of the organisms described here, only *M. epimetheus* produced gas with latex serum; the behaviour of this organism suggests that it may be a frequent cause of bubble formation in sheet rubber.

Van Harpen (5) has shown that the first coagulation zone of latex is entered at *p*H 4.77. It is known in estate practice that although acid may be added to the coagulating tank in quantity sufficient to lower the *p*H to this amount, it may not be sufficient to inhibit bubble formation. It would appear then that the gas forming organism is able to multiply at a *p*H 4.77, although it is destroyed when the *p*H is reduced to a lower value.

This is the case with *M. epimetheus*. It was found that good growth of the organism occurred in media of *p*H 4.7 to 9.0; when the *p*H was lowered to 4.4, the micrococcus disappeared. Gas formation as a result of the activity of *M. epimetheus* is completely inhibited, therefore, by ensuring that the *p*H value of the coagulating tank is not above 4.4.

Experimental.

The initial attempts at isolating latex bacteria were made by plating out latex, (4-6 hours old) on glucose agar. Such a procedure gave poor results, however, and it was found preferable to use a medium containing latex. A latex agar, having the composition;

1 c.c. fresh latex,
1.5 g. agar
1000 c.c. distilled water

gave satisfactory results and was employed throughout the investigation. No attempt was made to study all the organisms isolated, but eight forms submitted to detailed examination were selected because their colony forms suggested they were different species and this proved to be the case.

Little difficulty was experienced in isolating pure cultures, and growth was maintained on latex agar slants, sub-cultures being made at intervals of 7—10 days. Frequently it proved difficult to obtain plate cultures after the organisms had been growing on slants for some time and when this procedure was successful growth was not as vigorous as in the initial plating.

In general, the tests carried out followed the Descriptive Chart used by the Society of American Bacteriologists (7) and index numbers have been allotted in accordance with this schedule.

Several of the organisms studied are almost certainly identical with species isolated by Denier and Vernet in spite of the fact that divergence between corresponding species is often shown in the Gram staining and gelatine liquefaction tests. These are probably not very serious differences for the Gram staining test is often affected by the

age of the culture, whilst in the Tropics, considerable care has to be exercised to ensure satisfactory results with the gelatine liquefaction test. Gelatine media require careful preparation and frequently liquefy even when sterile. The new species here described were tested all at one time with freshly prepared gelatine media and no liquefaction of controls took place.

Description of the Organisms.

Most of the organisms isolated from latex are more closely related to bacteria found in the animal body than to soil bacteria. Thus *Gaffkya verneti* is closely allied to *G. tetragena* (Gaffky), which has been isolated from the mucous membrane of man, whilst *Micrococcus ridleyi* is near to *M. subgranulatus* Freund which is found in the oral cavity.

All the organisms described here were found to be Gram positive; few liquefied gelatine and only *B. pandora* and *M. epimetheus* gave positive results with the tests for nitrate reduction, indole production and fermentation of the commoner sugars.

Bacillus pandora and, probably, *Gaffkya verneti* alone were able to form spores. These organisms correspond closely to species isolated in Annam and so appear to be widely distributed.

Three of the species of micrococcus described produced yellow pigments with latex. This colour formation was most marked with *M. eatoni* but the pigment produced in this case was soluble in water and so would largely disappear from the rubber during the preparation process.

CLASS SCHIZOMYCETES
ORDER EUBACTERIALES
FAMILY COCCACEAE.

Gaffkya verneti sp.n

Index number: 3x01-U1105—0000

Denier and Vernet, Le Caoutchouc, 1920, **17**, 10491: *Organism No. 21.*

This species, like the generic type, *G. tetragena,* possesses a pseudocapsule but not a true capsule. Although the presence of spores was not definitely established, the fact that the organism can withstand 10 minutes' heating at 85°C. strongly suggests spore formation.

Microscopic Features.

Form: 3 (micrococci)

Almost invariably the organism occurred as a tetrad, the centres of the four spheres being in one plane.

Endospores:

The organism was not killed by heating at 85°C. for 10 minutes. The usual staining methods, however, failed to establish the presence of endospores.

Flagella: 0 (absent)

The organism was non-motile.

Gram stain: 1 (positive).

Miscellaneous Biochemical Reactions.

Biological relationships: U (undetermined)
Relation to oxygen: 1 (strict aerobe)
Gelatine liquefaction: 1 (positive)
In nitrate media: 0 (neither nitrite nor gas)
Chromogenesis: 5 (yellow)

The culture was lemon-yellow on agar and the intensity of the colour increased with age.

Carbohydrate Reactions.

Diastatic action: 0 (negative)
Glucose: 0 (no acid)
Lactose: 0 (no acid)
Sucrose: 0 (no acid)

Vegetative Cells.

Diameter: 2 (between 0.5 and 1.0 μ)

The average diameter of the cells was 0.9 μ.

Length: 1 (less than 2 diameters)
Chains: (4 or more cells): 0 (absent)
Capsules: 0 (absent)

Spores. See under " Endospores " above.

Cultural Features.

Agar stroke: beaded, pale yellow, flat and dull.

Growth moderate.

Agar colonies: pale yellow, circular.
Litmus milk: no visible change.
Indole production: negative.

Additional Reactions.

Nutrient broth: slightly turbid with sediment at the bottom of the tube.

Arabinose: neither acid nor gas.
Ammonia production: positive.
Hevea latex: no visible change and no evolution of hydrogen sulphide.
Latex serum: no acid produced; the only visible change was the formation of a yellow ring round the sides of the test-tube at the surface of the medium.

Differs from *G. tetragena* (Gaffky) in the non-production of acid from glucose and lactose, in liquefying gelatine and in the production of a lemon-yellow pigment in various media.

Isolated from Hevea latex, Selangor, F.M.S.

Micrococcus eatoni sp. n.

Index number: 3001-—U1005—0000.

Microscopic Features.

Form: 3 (micrococci)
Occurs as irregular masses of adhering cocci.
Endospores: 0 (absent)
The organism was killed by heating for 10 minutes at 85°C.
Flagella: 0 (absent)
The organism was non-motile.
Gram stain: 1 (positive)

Miscellaneous Biochemical Reactions.

Biological relationships: U (undetermined)
Relation to oxygen: 1 (strict aerobe)
Gelatine liquefaction: 0 (negative)
In nitrate media: 0 (neither nitrite nor gas)
Chromogenesis: 5 (yellow)
Cultures on agar had a pale yellow colour, the intensity of which increased with age.

Carbohydrate Reactions.

Diastatic action: 0 (negative)
Glucose: 0 (no acid)
After several days growth a slight reddening of the litmus was noticeable.
Lactose: 0 (no acid)
Sucrose: 0 (no acid)

Vegetative Cells.

Diameter: 3 (over 1.0 μ)
Length: 1 (less than 2 diameters)
The cells had an average diameter of 1.2 μ and an average length of 1.5 μ; there was very little variation in size.
Chains (4 or more cells): 0 (absent)
Capsules: 0 (absent)

Spores. See under " Endospores " above.

Cultural Features.

Agar stroke: filiform, yellow, flat and glistening. Growth moderate.
Agar colonies: yellow, opaque and lentiform.
Litmus milk: the medium became alkaline and peptonisation occurred. No gas was evolved.
Indole production: negative.

Additional Reactions.

Nutrient broth: slightly turbid with sediment at the bottom of the tube.
Arabinose: neither acid nor gas.
Ammonia production: positive.
Hevea latex: no visible change beyond the formation of a small amount of yellow scum on the surface. A little hydrogen sulphide was evolved.
Latex serum: no acid or alkaline production; a yellow ring formed at the surface of the liquid.

Differs from *M. aurantiacus* Schröter in its growth an agar stroke, in its action on milk and in other less important respects.

Isolated from Hevea latex, Selangor, F.M.S.

Micrococcus ridleyi. sp.n.
Index No. 3001—U1105—0200.

Microscopic Features:

Form: 3 (micrococci)
The cells occurred in irregular masses but pairs were observed occasionally.
Endospores: 0 (absent)
The organism was unable to survive heating for 10 minutes at 85°C.
Flagella: 0 (absent)
The organism was non-motile.
Gram stain: 1 (positive)

Miscellaneous Biochemical Reactions.

Biological relationships: U (undetermined)
Relation to oxygen: 1 (strict aerobe)
Gelatine liquefaction: 1 (positive)
In nitrate media: 0 (neither nitrite nor gas)
Chromogenesis: 5 (yellow)
Young cultures possessed a very pale straw colour but older cultures became pale yellow in colour.

Carbohydrate Reactions.

Diastatic action: 0 (negative)
Glucose: 2 (acid without gas)
Litmus decolourised.
Lactose: 0 (no acid)
Sucrose: 0 (no acid)

Vegetative Cells.

Diameter: 2 (between 0.5 and 1.0 μ)
Length: 1 (less than 2 diameters)
The cells were very uniform in size, having a diameter of 0.64 μ.
Chains (4 or more cells: 0 (absent)
Capsules: 0 (absent)

Spores. See under " Endospores " above.

Cultural Features.

Agar stroke: filiform, pale yellow, raised, moist and glistening. Growth moderate.
Agar colonies: white, opaque and oval.
Litmus milk: no acid or alkali produced; litmus decolourised. The milk showed slight signs of rennet curd formation.
Indole production: negative.

Additional Reactions.

Nutrient broth: the liquid remained clear but became slightly yellowish in colour. A yellow scum appeared at the surface and a sediment was present at the bottom of the medium.

Arabinose: neither acid nor gas.

Ammonia production: positive.

Hevea latex: no visible change or liberation of acid or hydrogen sulphide.

Latex serum: no visible change beyond the formation of a yellow ring at the surface of the liquid.

Very near to *M. subgranulatus* Freund but differs from it sufficiently to merit consideration as a distinct species.

Isolated from Hevea latex, Selangor, F.M.S.

Micrococcus epimetheus sp. n.

Index number: 3001—U2010—1111

The biochemical reactions of this species are similar in many respects to those of *B. pandora,* and when it was found that *M. epimetheus* showed a tendency towards rod formation, the possibility of the two organisms being identical was considered. There is no doubt however that the two are distinct, for *M. epimetheus* differs from the bacillus in its inability to form spores, in producing gas with latex serum and in its action on methyl l-inositol.

Microscopic Features.

Form: 3 (micrococci)

Usually occurred as irregular groups of cocci but occasionally the cells showed a tendency towards formation of short, stout rods.

Endospores: 0 (absent)

The organism was unable to survive heating at 85°C. for 10 minutes.

Flagella: 0 (absent) The organism was non-motile.

Gram stain: 1 (positive) The organism was stained by Gram's method in presence of *Bacillus pandora* which was known to be Gram positive. Both organisms stained equally well.

Miscellaneous Biochemical Reactions.

Biological relationships: U (undetermined)

Relation to oxygen: 2 (facultative anaerobe)

Gelatine liquefaction: 0 (negative)

In nitrate media: 2 (nitrite but no gas)

Chromogensis: 0 (none)

Carbohydrate Reactions.

Diastatic action: 1 (positive)
Glucose: 1 (acid and gas)
Litmus was rapidly decolourised. Gas production was less rapid with lactose and sucrose than with glucose.
Lactose: 1 (acid and gas)
Sucrose: 1 (acid and gas)

Vegetative Cells.

Diameter: 2 (between 0.5 and 1.0 μ)
Length: 1 (less than 2 diameters)
The normal coccus form had an average diameter of about 1.0 μ. The average of 10 measurements of the rod form was diameter 0.97 μ and length 1.35 μ.
Chains (4 or more cells): 0 (absent)
Capsules: 1 (present)
Observed by the Hiss method of staining.

Spores. See under "Endospores" above.

Cultural Features.

Agar stroke: filiform, colourless, raised, moist and glistening Growth moderate.
Agar colonies: white, opaque and lentiform.
Litmus milk: acid sufficient for curdling produced; litmus decolourised.
Indole production: positive.

Additional Reactions.

Nutrient broth: turbid with a sediment at the bottom of the tube. A little hydrogen sulphide was evolved.
Arabinose: acid and gas.
Ammonia production: positive.
Hevea latex: flocculating action observed on a 1 in 5 diluted latex. Hydrogen sulphide was evolved.
Latex serum: acid and gas produced.
Relation of growth to reaction of medium: Good growth occurred between pH = 4.7 and pH = 9.0; the limit for growth on the acid side was at pH = 4.4.

Isolated from Hevea latex, Selangor, F.M.S.

Micrococcus chersonesia sp. n.

Index number: 3001—U1000—0000

This organism is of considerable scientific interest in that it exhibits the phenomenon of dimorphism, occurring both in coccus and rod forms.

When originally plated out on latex agar, the colony consisted of a white, opaque, lentiform, central patch surrounded by a white, translucent, circular area. Whilst the lentiform patch was clearly defined, the marginal area was irregular. The inner area contained only cocci whilst the outer area comprised both cocci and rods.

When grown in ordinary culture media, the cocci gradually disappeared so that the rod form was the more stable type under ordinary laboratory conditions.

On replating after a lapse of 3 months, the inner smooth region comprised only cocci while both cocci and rods were found in the marginal area. Further replating, 3 months later, gave white, opaque and somewhat irregular margined colonies which contained only cocci.

No differences in biochemical reactions between the two forms were detected, but this point was not investigated closely as it was difficult to ensure the absence of the rod form.

Of recent years some attention has been paid to variability amongst bacteria and it has been found that the phenomenon is not infrequent. Dissociation amongst the members of the colon-typhoid —dysentery group has been investigated by Arkwright (8) who found that two colony forms occurred with each species. One, termed the S or smooth type, was circular, regular and opaque and possessed a smooth surface, whilst the R or rough form was irregular, translucent and with a rough surface. One type was usually the more stable under laboratory conditions, and on ageing of the cultures, this form persisted to the exclusion of the other. Several other instances of this variation in colony form are known and such cases are usually associated with differences in the forms of the organisms.

This phenomenon of dissociation places difficulties in the path of the systematist, but in the case of *M. chersonesia* it appears to the writer that it should be classed with the Coccaceae rather than with the Bacteriaceae, because the coccus form was first isolated and always predominated in new colonies.

Microscopic Features.

Form: 3 (micrococci)

The cells contained in the agar colonies occurred as irregular groups of cocci and as short, stout rods. The coccus form was almost constant in size but the rods varied considerably.

Endospores: 0 (absent)

The organism was unable to withstand heating at 85°C. for 10 minutes.

Flagella: 0 (absent)

Both the coccus and rod forms appeared to be non-motile but some difficulty was experienced in deciding this point. No flagella were detected after staining by Loeffler's method.

Gram stain: 1 (positive)

Miscellaneous Biochemical Reactions.

Biological relationships: U (undetermined)
Relation to oxygen: 1 (strict aerobe)
Gelatine liquefaction: 0 (negative)
In nitrate media: 0 (neither nitrite nor gas)
Chromogenesis: 0 (none)

Carbohydrate Reactions.

Diastatic action: 0 (negative)

The diastatic action was very feeble.

Glucose: 0 (no acid)
Lactose: 0 (no acid)
Sucrose: 0 (no acid)

Vegetative Cells.

Diameter: 2 (between 0.5 and 1.0 μ)

The average diameter of the coccus form was 0.53 μ. The rods varied considerably in size and form but the average diameter was 0.7 μ and the average length 1.4 μ.

Length: 1 (less than 2 diameters)
Chains (4 or more cells): 0 (absent)
Capsules: 0 (absent)

Spores. See under "Endospores" above.

Cultural Features.

Latex agar stroke: filiform, colourless, flat and dull. Growth moderate.

Latex agar colonies: the colony on agar consisted of a white, opague, lentiform patch surrounded by a white, translucent, circular area. The lentiform patch contained the coccus form while the outer area contained cocci and short rods.

Litmus milk: no visible change.
Indole production: negative.

Additional Reactions.

Nutrient broth: turbid with sediment at the bottom of the tube.
Arabinose: neither acid nor gas.
Ammonia production: positive.
Hevea latex: no visible change and no evolution of hydrogen sulphide.
Latex serum: no visible change and no acid production.

Isolated from Hevea latex, Selangor, F.M.S.

FAMILY BACTERIACEAE.

Alcaligenes denieri sp. n.

Index number: 5001—U1000—0000

Denier and Vernet, loc. cit. *Organism No. 6.*

The slightly curved rods of this species are rather distinctive and give it a *Vibrio*-like appearance. The production of alkalinity with milk is slow but quite definite.

Microscopic Features.

Form: 5 (rods)
Flexuous rods with round ends; frequently the rods are slightly curved.
Endospores: 0 (absent)
Heating for 10 minutes at 85°C. destroys the organism.
Flagella: 0 (absent)
The organism was not motile.
Gram stain: 1 (positive)

Miscellaneous Biochemical Reactions.

Biological relationships: U (undetermined)
Relation to oxygen: 1 (strict aerobe)
Gelatine liquefaction: 0 (negative)
In nitrate media: 0 (neither nitrite nor gas)
Chromogenesis: 0 (none)

Carbohydrate Reactions.

Diastatic action: 0 (negative)
Glucose: 0 (no acid)
Lactose: 0 (no acid)
Sucrose: 0 (no acid)

Vegetative Cells.

Diameter: 2 (between 0.5 and 1.0 μ)
Length: 2 (more than 2 diameters)
The rods had an average diameter of 0.8 μ and an average length of 2.9 μ.
Chains (4 or more cells): 0 (absent)
Capsules: 0 (absent)

Spores. See under " Endospores " above.

Cultural Features.

Latex agar stroke: filiform, colourless, flat and dull. Growth moderate.
Latex agar colonies: circular.
Litmus milk: slow production of alkalinity.
Indole production: negative.

Additional Reactions.

Nutrient broth: liquid clear with a little sediment at the surface and at the bottom of the tube.
Arabinose: neither acid nor gas.
Ammonia production: only a trace of ammonia evolved.
Hevea latex: no visible change and no hydrogen sulphide liberated.
Latex serum: no change detected.

Very near to *Alcaligenes albus* Bergey et al, which has been isolated from the udder of the cow.

Isolated from Hevea latex, Selangor, F.M.S.

FAMILY BACILLACEAE.

Bacillus pandora Corbet.

J. Bacteriology, 1930, **19**, 321.
Denier and Vernet, loc. cit. *Organism No. 1.*
B. pandora has no visible action on litmus arabinose.

FUNGI IMPERFECTI

Torula heveae sp. n.

In the opinion of the writer, this organism gave sufficiently distinctive reactions to merit recognition as a distinct new species.

Microscopic Features.

Form: on agar and in sugar solution, the cells were spherical although a tendency towards an ellipsoidal form was often noticeable.

Diameter: the cells varied considerably in size but the diameter usually ranged between 1.6 μ and 4.1 μ although larger and smaller cells were measured.

Multiplication: occurred by budding and frequently daughter cells were observed budding before separation from the mother cell. Two or more buds often formed simultaneously on the same cell.

Ascospore formation: no ascospore formation was observed on blocks of plaster of Paris.

Staining: the cells were stained readily by carbol-fuchsin. Each cell contained a fat globule, the presence of which was demonstrated by staining with Sudan III.

Miscellaneous Biochemical Reactions.

Gelatine liquefaction: positive.

Nitrate media: no evidence of reduction obtained.

Chromogenesis: cultures on agar were chalky-white in colour.

Ammonia: formed in glucose-peptone-agar after 5 days.

Hevea latex: no visible change occurred in a sterile 10 per cent. latex.

Carbohydrate Reactions.

	After 5 days.	*After 3 weeks.*
Litmus lactose	No acid, no gas	Acid and gas
Litmus glucose	No acid, no gas	Acid, no gas
Litmus sucrose	Inverted, no acid, no gas	Acid and gas
Litmus maltose	No acid, no gas	No acid, no gas
Litmus arabinose	No acid, no gas	Not tested

A small amount of sediment was found at the bottom of each tube.

Cultural Features.

Glucose agar stroke: raised, glistening, smooth and chalky-white in appearance. On older cultures the edges of the stroke had a beaded appearance. Growth was rapid on glucose-agar and on Thornton's agar. Good growth occurred throughout the length of a latex-agar stab culture.

This organism appears to be very near to Torula No. 5 and Torula No. 6 of Hansen (9) but this author gives very meagre details concerning these organisms.

Isolated from Hevea latex, Selangor and Perak, F.M.S.

Summary.

Certain micro-organisms are described which have been isolated from the latex of *Hevea brasiliensis*. Of these, *Bacillus pandora* and *Micrococcus epimetheus* are of interest in that both produce acid in latex and the last named is also responsible for gas formation. The bearing of these organisms on the process of natural coagulation is discussed.

Micrococcus chersonesia is dimorphic, occurring in two colony forms which are associated with difference in the forms of the organisms.

Three species produce yellow pigments with latex but as the coloured substances are soluble in water, they are largely removed from the rubber during the preparation process.

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OBSERVATIONS ON THE COAGULATION OF HEVEA LATEX.

BY

R. G. Fullerton.

Introduction.

A great deal of attention has been given to a study of coagulation phenomena in rubber latex, but, until recently, investigations have been hampered by the absence of a satisfactory method for the accurate definition of the various stages in the coagulation process in terms of the hydrogen ion concentration of the medium. Among the first to draw attention to the importance of establishing satisfactory methods for the measurement of hydrogen ion concentration was Belgrave (1) who made use of the hydrogen electrode and compared the results of electrometric measurements with those obtained colorimetrically by means of indicators. He found that results obtained electrometrically in this way were uncertain owing to coagulation of the latex on the platinised hydrogen electrode, and with indicators it is difficult to make colorimetric comparisons when working with a cloudy liquid. More recently, however, van Harpen (2) and van Dillen (3), have made use of the quinhydrone electrode to make more accurate observations of the various stages in the process. The present paper describes some observations which have been made with the aid of the quinhydrone electrode applied to the study of hydrogen ion concentration of latex under the influence of acids and certain preservatives.

Technique.

The technique followed in the making of measurements and the assembly of the apparatus followed very closely that recommended by Biilmann and Tovborg-Jensen (4) for the determination of pH values in soil-water mixtures. In both electrodes the metallic electrode used was a piece of bright platinum foil, about 1 centimetre square, welded to a platinum wire fused into a glass tube. The standard electrode used was the quinhydrone electrode, the electrolyte of which was prepared by mixing 900 c.cs of $\frac{N}{10}$ KCl. with 100 c.cs of $\frac{N}{10}$ HCl. The potential was measured by means of the portable type of potentiometer supplied by the Cambridge Instrument Co., Ltd. Before making a series of determinations the apparatus was standardised by measuring the pH in a standard buffer solution of known composition. For this purpose an $\frac{M}{20}$ solution of potassium hydrogen phthalate was used, the pH of which is 3.97 between 20° and 30°C. The quinhydrone was prepared according to the methods recom-

mended by Biilmann and Lund, (4) 0.1. g. of the solid being added per 25 c.c. of solution in either of the two electrode vessels.

For this system Biilmann has developed the equation:—

$$pH = 2.03 + \frac{\pi}{0.0001984 \times T}$$

where π is the measured potential in volts and T is the absolute temperature. He has shown that for a temperature fluctuation in the electrode of $\pm$ 1°C the error introduced is not greater than 0.05 of a unit of pH. Since room temperature in the tropics is fairly constant at 29° $\pm$ 1°C, a thermostat was not used in the experiments to be described. For each single measurement the temperature of the solution, whose pH was to be determined, was recorded and it was found that the average fluctuation about the value 29°C was 0.5°.

For determinations of the pH of latex in a state of flocculation or coagulation the pH values of the sera were obtained.

Before proceeding with the main investigation it was necessary to determine (a) whether there is an appreciable drift of potential in making a measurement with latex and (b) the accuracy with which results can be reproduced for the same latex within reasonable limits of time.

To determine the first point fresh undiluted latex and the same latex diluted to a low rubber content were examined. Two samples —A and B—from different groups of trees on the same estate were collected shortly after tapping. Diluted latices, in the proportion latex : water = 1 : 9, were prepared from each of the two original samples, and all four latices allowed to stand for about 15 minutes with occasional gentle stirring. Measurements were then taken in the order—sample A undiluted, sample A diluted, sample B undiluted, sample B diluted. For each series of measurements the procedure was as follows:—

Quinhydrone was added to a portion of the sample in a test-tube —about 0.1 g. per 25 c.c. latex—and the mixture stirred together for a few seconds with a glass rod. The test-tube with contents was then placed in position in the apparatus, which had previously been standardised and tested. A reading for E.M.F. was then taken as soon as possible and the time for this referred to as zero. Readings were then taken for the sample at definite intervals, usually 10 seconds, over a total period of about 10 minutes. The test-tube was then removed and the platinum electrode was cleaned by rinsing with distilled water and heating to redness. The apparatus was then standardised and made ready for the next series of measurements. The pH of all four samples was then determined after a period of four hours. Table I summarises the results obtained. It will be seen that the potential attains its maximum value almost immediately and there is, thereafter, a slight drift in the direction of decreasing

TABLE I.

Drift of Potential with Time.

Latex Sample A.				Latex Sample B.			
Undiluted		Diluted 1: 9		Undiluted		Diluted 1: 9	
Time in Secs.	pH.	Time in Secs.	pH.	Time in Secs.	pH.	Time in Secs.	pH.
0	6.80	0	6.48	0	6.81	0	6.42
10	,,	10	,,	10	,,	10	,,
20	,,	20	,,	20	,,	20	,,
30	,,	30	,,	30	,,	30	,,
40	,,	40	,,	40	,,	40	,,
50	6.79	50	,,	50	6.80	50	,,
60	,,	60	6.47	60	,,	60	6.41
70	,,	70	,,	70	,,	70	,,
80	,,	80	,,	80	,,	80	,,
90	,,	90	,,	90	,,	90	,,
100	,,	100	,,	100	,,	100	,,
130	,,	110	,,	110	,,	110	,,
160	,,	120	,,	120	,,	120	,,
190	,,	120	,,	130	,,	130	,,
220	6.78	140	,,	140	,,	140	,,
250	,,	150	,,	150	,,	150	,,
280	,,	160	6.46	160	,,	160	6.40
310	6.77	170	,,	170	,,	170	,,
340	,,	200	,,	180	6.79	200	,,
370	,,	230	,,	190	,,	230	6.39
400	6.76	290	6.45	200	,,	290	,,
430	,,	350	,,	230	,,	350	,,
460	,,	370	,,	260	,,	370	,,
490	6.74	390	,,	290	6.77	390	6.37
520	,,	410	6.43	310	,,	400	,,
550	,,	430	,,	340	,,	430	,,
580	6.73	450	,,	370	,,	450	6.36
610	,,	470	6.42	400	6.76	470	,,
After 4 hours.	6.50	After 4 hours	6.24	After 4 hours.	6.55	After 4 hours	6.22

pH. In what follows, therefore, the initial reading for the E.M.F. was taken as the true value.

As regards agreement in repeat measurements, Table II gives the results of a few determinations for two samples of fresh latex—A and B—and latices prepared from each of these by dilution with distilled water, as before in the proportion latex : water = 1 : 9. The procedure was to stir the bulked latex thoroughly and then pour

about 15 c.cs into each of a series of glass tubes of approximately the same diameter in order that uniform conditions might obtain. Measurements were then carried out at definite intervals of time for each member of this series of samples. It will be seen that the values for latex, both diluted and undiluted, remain fairly constant within a period of about half-an-hour, which period is of course ample in practice for the performance of several determinations of pH.

TABLE II.

Agreement in Readings for a series of samples taken from the same latex.

Latex Sample A.				Latex Sample B.			
Undiluted.		Diluted 1.9.		Undiluted.		Diluted 9.	
Time Mins.	pH.	Time Mins.	pH.	Time. Mins.	pH.	Time Mins.	pH.
0	6.80	0	6.52	0	7.01	0	6.77
5	6.81	12	6.52	5	7.00	10	6.77
10	6.79	27	6.51	10	7.01	21	6.75
15	6.80	37	6.52	15	7.00	30	6.76
20	6.80	47	6.54	20	7.01	35	6.77
25	6.80	66	6.52	25	7.02	45	6.77
30	6.81	77	6.54	30	7.00	65	6.76
35	6.79	85	6.53	35	7.01	80	6.75

In what follows, before each determination of pH, it was found necessary to rinse the negative electrode with distilled water and to heat the platinum to redness in a sulphur-free flame.

EXPERIMENTAL.

A. Fresh Latex.

If latex is examined within about 2 hours after its exudation from the tree it is found to be very nearly neutral. The pH values of a large number of samples collected at various periods of the year ranged from 7.02 to 6.80. If the latex is allowed to stand so that

its surface is exposed to the atmosphere, for the first 5 or 6 hours after tapping the pH remains very nearly constant. Thereafter clotting commences, accompanied by a more rapid increase in hydrogen ion concentration, until finally within a period of about 24 hours coagulation takes place. The coagulation is not, however, usually complete, that is to say, one does not find only a coherent coagulum floating in a clear serum. If the storage vessel is of sufficient depth one finds on the surface a shallow layer of thick alkaline slime of fairly high rubber content, then a deeper layer of coherent coagulum, and beneath a watery serum with a distinctly acid reaction, usually milky and still containing a few latex particles in suspension. In Table I the figures for undiluted latex show the course of the changes in hydrogen ion concentration within the first 4 hours after tapping. It is not possible to measure with a great degree of accuracy by the quinhydrone electrode the pH of the various layers which form as the result of this spontaneous coagulation since the changes are accompanied by a free evolution of hydrogen sulphide gas which may bring about poisoning of the electrodes. By means of indicators, however, it was ascertained that the pH of the surface layer was in the cases examined distinctly on the alkaline side of neutrality—from 7.5 to 8.0—while the pH of the serum resulting from the coagulation ranged from 6.3 to 6.5.

If a series of latex samples is prepared and examined in order of increasing hydrogen ion concentration it is found that there is first a range of pH values defining a condition of the sol which may be described as complete dispersion. By this is meant that no aggregation of the latex particles sufficient to cause separation of the whole or part of the disperse phase has taken place. This is followed by a range or zone within which the latex is coagulated. For still higher values of hydrogen ion concentration there is again a zone of complete dispersion and finally at the end of the scale a further range within which coagulation is again complete. As will be shown, later, the degree of dispersion in the various zones is influenced by several factors, principally by the rubber content of the latex, the transition from one zone or range to another is gradual, and, depending on the dilution of the latex, another set of values defining a condition intermediate between coagulation and dispersion may be obtained. Such a discontinuity has been observed in the flocculation of other colloidal sols by electrolytes—e.g. the flocculation of a negatively charged sol of mastic by $AlCl_3$—and these phenomena have been designated by the term " irregular series."

In studying the different zones defining various conditions of the dispersion, the procedure was to add increasing quantities of an acid coagulant in fixed concentration to a series of latex samples of equal volume and to examine the samples after a period of 24 hours. By choosing coagulation vessels of the same shape and

dimensions for each member of the series, conditions under which changes in the pH of the system might occur within the period allowed for examination were kept as uniform as possible. Within such a period sufficient time is allowed for changes that occur in the dispersion to reach a stage at which they can be definitely characterised by their appearance and other properties. For example, the initial stages in coagulation may occur four hours after the addition of the coagulant without the visible separation of the latex into two layers, coagulum and serum. It is therefore difficult to characterise the condition of the dispersion at this stage. After a further period, however, the process may have reached a stage at which separation into coagulum and serum is distinctly discernible, and where from the appearance of the serum the coagulation may be described as partial or complete, as the case may be. By the addition of the coagulant in the manner stated the initial dry rubber content of the latex is lowered, but the concentration of the coagulant was so chosen that the dilution of the latex caused by its addition was very slight. When a greater interpolation of pH values was required for the transition from one boundary to another, a suitable buffer salt solution was added to the latex before the addition of the coagulant.

In tabulating the results the following system is adopted for the description of the condition of the dispersion after the period stated.

Complete Dispersion.—This describes a condition where the latex is homogeneous and completely liquid having the same appearance microscopically as pure latex examined soon after tapping. The particles are in vigorous Brownian motion and aggregation of the particles has not occurred to such an extent that there is a separation of rubber from the dispersion either in the form of a flocculate or a coherent clot of coagulum.

Partial Flocculation.—There is a separation from the dispersion of floccules which can be seen microscopically to consist of large aggregates of smaller rubber particles. The separation to the surface in the form of a flocculate is not complete, the underlying serum being milky in appearance and still containing a high proportion of rubber particles in suspension. The flocculate can be re-dispersed by shaking the tube and separation does not thereafter recommence for a considerable time.

Complete Flocculation.—The separation of rubber from the latex in the form of a flocculate is complete, the underlying serum being water-clear and practically free from rubber globules in suspension. As in the case of partial flocculation the same remarks apply to the reversibility of the flocculate.

Partial Coagulation.—There is a separation in the form of a coherent coagulum or clot, but a large proportion of rubber remains in suspension in the serum which is milky-white in appearance.

Coagulation almost complete.—There is a separation in the form of a coherent irreversible coagulum but the separation is not complete. The underlying serum is slightly cloudy and still contains a small proportion of rubber particles in suspension.

Complete Coagulation.—There is complete separation in the form of a coherent coagulum and a clear serum.

In Diagram I an attempt has been made to present the salient features differentiating the various conditions described above. The diagram has been constructed from the data set forth for the third series in Table III which will be discussed later.

Latex of 4 per cent. Rubber Content.

By working with latex of low rubber content it is possible to demonstrate more clearly than with undiluted latex the gradual changes which accompany the transition from one zone to another. Fresh latex was diluted to a dry rubber content of 4 per cent. and buffered with a 10 per cent. solution of ammonium acetate before the addition of the coagulant in the form of a 2.5 per cent. solution of acetic acid.

The buffer solution was added in three different proportions and corresponding to each proportion a separate series of latex samples was prepared. Table III summarises the results obtained. In the first series complete coagulation occurs at a pH of 4.81, in the second at pH of 4.84 and in the third at pH of 4.83. It will be seen that the transition from a condition of complete dispersion, or from the first liquid zone to the first coagulation zone is accompanied by a progressive series of changes. With increasing hydrogen ion concentration we pass through intermediate stages of partial coagulation before complete coagulation results. The third series gives the clearest picture of what occurs since here the gradations in pH are smaller. By reference to Table III and to Diagram I it will be seen that the transitional stage is defined by the range pH 5.30 to 4.91.

On repeating this experiment with latex collected from the same group of trees on different days, different results were obtained, for the pH values defining the commencement of complete flocculation and of complete coagulation. Table IV shows how these values vary. The transition is irregular and somewhat ill-defined. Taking the average of the values obtained one finds that complete flocculation commences at pH 5.03 and complete coagulation at pH 4.87. Van Harpen, (2) working in Sumatra, finds for latex of approximately the same rubber content the values pH 5.05 and pH 4.77 respectively. It is probable that differences in latex composition are responsible.

In order to bring the latex into the second liquid zone or second zone of complete dispersion a stronger acid is required as coagulant.

TABLE III.

FRESH LATEX.

Dry Rubber Content = 4 per cent.

First Liquid Zone to First Coagulation Zone.

c. c of 2.5 per cent. Acetic acid per 50 c.c latex.	c.c of 10 per cent. Ammonium acetate per 50 c.c latex.	Condition after 24 hours.	pH.
0.2	0.5	Partial flocculation	5.29
0.4	,,	,,	5.16
0.6	,,	,,	5.03
0.8	,,	,,	5.01
1.0	,,	Coagulation almost c'plete	4.98
1.2	,,	,,	4.89
1.4	,,	Complete coagulation	4.81
1.6	,,	,,	—
1.8	,,	,,	—
2.0	,,	,,	—
0.2	1.0	Partial flocculation	5.32
0.4	,,	,,	5.20
0.6	,,	,,	5.13
0.8	,,	Complete flocculation	5.08
1.0	,,	,,	4.96
1.2	,,	Coagulation almost c'plete	4.91
1.4	,,	Complete coagulation	4.84
1.6	,,	,,	—
1.8	,,	,,	—
2.0	,,	,,	—
2.2	,,	,,	—
2.4	,,	,,	—
2.6	,,	,,	—
2.8	,,	,,	—
3.0	,,	,,	—
3.2	,,	,,	—
3.8	,,	,,	—
4.0	,,	,,	—
0.2	1.5	Complete dispersion	6.02
0.6	,,	,,	5.70
0.8	,,	,,	5.55
0.9	,,	,,	5.45
1.0	,,	Partial flocculation	5.30
1.3	,,	,,	5.20
1.5	,,	,,	5.13
1.8	,,	,,	5.09
2.0	,,	Complete flocculation	5.01
2.2	,,	,,	4.93
2.5	,,	Coagulation almost c'plete	4.91
2.8	,,	Complete coagulation	4.83
3.0	,,	,,	4.81
3.5	,,	,,	4.73
3.7	,,	,,	4.69
4.0	,,	,,	4.66
4.5	,,	,,	4.63
4.7	,,	,,	4.56

This also applies for latex within the second zone of coagulation. Table V shows the results obtained using hydrochloric acid. It will be seen that the transition from one zone to another is not accompanied by so many changes in the state of dispersion as is the case when passing from the first liquid zone to the first coagulation zone, and the ranges of pH defining the transitional stages are smaller. The flocculated condition does not make its appearance although the gradations in pH are small. Taking the series in order of increasing hydrogen ion concentration, in the passage from the first coagulation zone to the second liquid zone a condition of complete dispersion first makes its appearance at pH 3.52, and this condition persists until a pH of 0.83 is reached, until complete coagulation results at a pH value of 0.82.

The foregoing results are conveniently summarised in Table VI.

TABLE IV.

Fresh Latex.

Dry Rubber Content 4 per cent.

Date of tapping	pH. Complete Flocculation.	pH. Complete Coagulation
22-6-29	5.01	4.74
23-6-29	5.08	4.78
24-6-29	4.98	4.93
25-6-29	5.11	4.96
1-7-29	5.00	4.87
3-7-29	4.95	4.84
4-7-29	5.03	4.74
5-7-29	5.02	4.88
15-7-29	4.96	4.88
18-7-29	5.02	4.87
19-7-29	5.14	5.04
Average	5.03	4.87

TABLE V.

Fresh Latex.

Dry Rubber Content = 4 per cent.

First Coagulation Zone to Second Liquid Zone.

c. c of $\frac{N}{10}$ H. Cl per 50 c. c. latex.	Condition after 24 hours.	pH.
0.5	Incomplete flocculation	—
1.0	,,	—
1.5	Complete coagulation	4.74
2.0	,,	—
2.5	,,	3.80
2.6	Coagulation almost complete	3.71
2.7	,,	3.65
2.9	,,	3.58
3.0	Complete dispersion	3.52
3.5	,,	3.20

Second Liquid Zone to Second Coagulation Zone.

c. c of N. H Cl. per 50 c. c. latex.	Condition after 24 hours.	pH.
0.8	Complete Dispersion	2.01
4.8	,,	1.26
6.0	,,	1.00
7.0	Partial Coagulation	0.88
8.0	,,	0.87
9.0	,,	0.83
10.0	Complete Coagulation	0.82
11.0	,,	0.76
12.0	,,	0.74
13.0	,,	0.71
14.0	,,	0.67
15.0	,,	0.66
16.0	,,	0.62

TABLE VI.

Fresh Latex.

Dry Rubber Content = 4 per cent.

——	pH Range.
Complete Dispersion, ...	>5.30
Partial Flocculation, ...	5.30 — 5.01
Complete Flocculation, ...	5.01 — 4.91
Coagulation almost complete, ...	4.91 — 4.83
Complete Coagulation, ...	4.83 — 3.80
Coagulation almost complete, ...	3.80 — 3.52
Complete Dispersion, ...	3.52 — 1.00
Partial Coagulation, ...	1.00 — 0.82
Complete Coagulation, ...	<0.82

Latex of 15 per cent. Rubber Content.

Dilution of the latex to a rubber content of 15 per cent., which is the standard dilution usually adopted in Malayan plantation practice, does not create very marked differences as compared with latex of greater dilution in the ranges of pH values defining the various zones in the irregular series. As will be seen from Tables VII and VIII and Table IX which summarises the results, there is a more extended range of values within which complete coagulation takes place in the first zone, and the range for flocculation is smaller. The first appearance of a flocculate occurs at pH 5.54 whereas in the previous case the lower value of 5.30 is required to bring about the first evidence of coagulation.

TABLE VII.

Fresh Latex.

Dry Rubber Content = 15 per cent.

First Liquid Zone to First Coagulation Zone.

c. c of 2. 5 per cent. acetic acid per 50 c.c of latex.	c. c of 10 per cent. ammonium acetate per 50 c.c of latex.	Condition after 24 hours.	pH.
0	1.0	Complete Dispersion	6.96
0.2	,,	,,	6.20
0.6	,,	,,	5.82
1.0	,,	Partial Flocculation	5.54
1.2	,,	,,	—
1.4	,,	,,	—
1.8	,,	Coagulation almost complete	5.24
2.0	,,	,,	—
2.2	,,	,,	—
2.4	,,	,,	5.04
2.6	,,	,,	4.94
3.0	,,	,,	4.82
3.5	,,	Complete Coagulation	4.78
3.8	,,	,,	—
4.0	,,	,,	—

First Coagulation Zone to Second Liquid Zone.

c. c of $\frac{N}{1}$ H.Cl. per 50 c.c of latex.	Condition after 24 hours.	pH.
0.2	Complete Dispersion	—
0.4	Coagulation almost complete	—
0.6	Complete Coagulation	—
0.8	,,	—
1.0	,,	3.70
1.2	,,	3.51
1.3	Coagulation almost complete	3.24
1.4	,,	3.01
1.5	Complete Dispersion	3.00
2.0	,,	—
3.0	,,	—

TABLE VIII.

Fresh Latex.

Dry Rubber Content = 15 per cent.

c. c of 10 N. HCl per 50 c. c of latex.	Condition after 24 hours.	pH.
0.2	Complete Dispersion	1.62
0.4	,,	—
0.6	Partial Coagulation	1.23
0.8	,,	—
1.0	,,	0.95
1.5	Complete Coagulation	0.74

TABLE IX.

Fresh Latex.

Dry Rubber Content = 15 per cent.

—	pH Range.
Complete Dispersion	>5·54
Partial Flocculation	5·54 — 5·24
Coagulation almost complete ...	5·24 — 4·78
Complete coagulation	4·78 — 3·51
Coagulation almost complete ...	3·51 — 3·01
Complete Dispersion	3·01 — 1.23
Partial Coagulation	1.23 — 0.73
Complete Coagulation	<0.73

Latex of 20 per cent. Rubber Content.

For the sake of brevity the detailed experimental results are not reproduced for latex diluted to a rubber content of 20 per cent. and Table X gives a summary. From this it will be seen that there is now a marked difference in the progress of the series. In the first place coagulation makes its appearance at a higher value than in the two preceding cases viz. at pH 5.80. But the main difference is found in the range of values within which latices of greater dilution are in the condition defined by the second liquid zone. With latex of 20 per cent. dry rubber content, between pH 3.02 and 0.60, a small clot of coherent coagulum is formed, although the rest of the latex remains in a state of complete dispersion. The percentage of the total rubber content separating as a clot was found to be roughly 2 per cent. the rest remaining in stable dispersion in the serum. There is, therefore, strictly speaking, no second liquid zone with latex of this rubber content. It will be seen also that a slightly higher hydrogen ion concentration is required before complete coagulation appears in the second coagulation zone—viz. pH 0.60—and that a region of flocculation does appear.

TABLE X.

Fresh Latex.

Dry Rubber Content = 20 per cent.

——	pH Range.
Complete Dispersion	>5.80
Coagulation almost complete ...	5.80 — 4.84
Complete Coagulation	4.84 — 3.51
Coagulation almost complete ...	3.51 — 3.02
Partial Coagulation	3.02 — 0.60
Complete Coagulation	<0.60

Latex of Rubber Content = 35 per cent.

Undiluted field latex was used for the tests and the differences here are very marked. The detailed results of a typical experiment are set out in Table XI and summarised in Table XII. Here coagulation first appears at a still higher value than in previous cases—

viz. pH 6.24—and flocculation does not occur. There is no second liquid zone. Within the range defined by pH 3.02 to 0.83, coagulation is almost complete and the serum is slightly milky. There are, therefore, only two zones in the series—a liquid zone and a coagulation zone.

TABLE XI.

FRESH LATEX.

Dry Rubber Content = 35 per cent.

c. c of 2.5 per cent. acetic acid per 50 c.c of latex.	c.c of 10 per cent. ammonium acetate per 50 c.c. of latex.	Condition after 24 hours.	p.H.
0.5	0.5	Complete Dispersion	6.31
1.0	,,	Partial Coagulation	6.20
2.0	,,	,,	—
3.0	,,	,,	—
4.0	,,	,,	—
5.0	,,	Complete Coagulation	4.71
7.0	,,	,,	—
c.c of N.HCl per 50 c.c. of latex.			
0.05	Nil	Complete Dispersion	6.28
0.2	,,	Partial Coagulation	6.24
0.3	,,	,,	—
0.4	,,	,,	—
0.5	,,	,,	5.31
1.0	,,	Complete Coagulation	4.49
2.0	,,	,,	3.37
2.2	,,	Coagulation almost c'plete	3.02
2.4	,,	,,	2.78
2.5	,,	,,	2.65
3.2	,,	,,	2.11
3.4	,,	,,	—
3.6	,,	,,	1.91
3.8	,,	,,	—
4.0	,,	,,	1.53
4.5	,,	,,	—
5.0	,,	,,	1.28
5.5	,,	,,	—
6.0	,,	,,	1.16
c.c of 10 N.HCl per 50 c.c of latex.			
1.0	Nil	Coagulation almost c'plete	—
1.5	,,	Complete Coagulation	0.83
2.0	,,	,,	—

TABLE XII.

Fresh Latex.

Dry Rubber Content = 35 per cent.

——	pH Range.
Complete Dispersion	>6.24
Partial Coagulation	6.24 — 4.71
Complete Coagulation	4.71 — 3.02
Coagulation almost complete ...	3.02 — 0.83
Complete Coagulation	<0.83

B. Heated Latex.

A study of the progress of changes for latex which has been boiled or pasteurised shows certain deviations from the normal course of the irregular series for pure field latex. Preparation was carried out according to the method which de Vries and Beumée-Nieuwland (5) adopt for boiled latex or "B" liquid. This was carried out by boiling nine volumes of water and quickly pouring in one volume of latex, boiling the mixture for a further period of three minutes and then allowing to stand for five minutes before cooling in running water to the temperature of the room. Latex so prepared remains as a fairly stable dispersion for several days. Experimental work with this latex was carried out on the day of preparation and the definitions adopted for the various states of dispersion are the same as those described for fresh latex.

To a portion of this "B" liquid, a solution of sodium oleate was added so that the concentration of soap in the latex was 0.01 per cent. by volume.

A sample of pure field latex diluted to the same rubber content, viz. 4 per cent, was treated similarly.

A comparison was then made between the three samples (1) "B" liquid, (2) "B" liquid + 0.01 per cent. of sodium oleate (3) Fresh latex + 0.01 per cent. of sodium oleate. The experimental results are summarised in Table XIII.

The observations of other workers, notably de Vries (6) and Belgrave, (7) are confirmed to the effect that "B" liquid merely flocculates for values of pH, for which fresh latex coagulates within the first coagulation zone. Coagulation does not occur until a pH of 0.80 is reached, a value which is practically the same as that observed for pure field latex. For "B" liquid the definitive values of pH for the various zones agree closely with those obtained by van Harpen (2).

By the addition of a small quantity of sodium oleate to "B" liquid, however, coagulation takes the same course as for pure latex—between pH 4.68 and 3.50 complete coagulation is obtained. In other words the addition of sodium oleate has brought about a coalescence of the floccules.

As compared with pure field latex of the same dilution it will be seen from Table XIII Column (3) that the addition of sodium oleate has caused the first appearance of separation from the dispersion to commence at a slightly lower hydrogen ion concentration viz. pH 5.24. Also coagulation is first complete at pH 4.95 as compared with the value 4.83 for pure latex.

During the course of this work it was noted that there is on occasions a slight rise in pH on heating. Samples were prepared from the same stock of fresh latex in the same way as for "B" liquid except that the temperature of heating was varied from room temperature (29°C) to 100°C. The measurements of pH were carried out when all the samples of the series had cooled to room temperature. Other conditions during preparation were kept as uniform as possible for each member of the series. Table XIV which gives the results obtained for two series prepared from different stock latices, A and B, shows that the pH tends to increase as the temperature of heating increases. The two cases quoted are, however, extreme. With some samples the rise in pH was very slight, although in all cases it was appreciable. A possible explanation is that carbon dioxide is lost from the system on heating thereby decreasing the acidity. Another factor which possibly acts in conjunction with the loss of carbon dioxide is the rise of pH which may take place as a result of denaturation of the proteins, since almost certainly some of the proteins are denatured by heating the latex to a high temperature. A rise of pH taking place as the result of the heat denaturation of egg albumin solutions has been observed by Chick and Martin (8).

TABLE XIII.

Condition	Ranges of pH. (1) "B" Liquid	(2) "B" Liquid +0.01 per cent. of Sodium oleate.	(3) Fresh Latex +0.01 per cent. of Sodium oleate.
Dispersion -	> 5.02	> 5.01	> 5.24
Flocculation -	5.02 - 3.52	5.01 - 4.68	5.24 - 4.95
Coagulation -	Does not occur	4.68 - 3.50	4.95 - 3.51
Dispersion -	3.52 - 0.80	3.50 - 0.82	3.51 - 0.83
Coagulation -	< 0.80	< 0.82	< 0.83

TABLE XIV.

Latex A		Latex B	
Temperature of Heating °C.	pH at 28°C.	Temperature of Heating °C.	pH at 28°C.
28	6.68	28	5.92
35	6.70	35	5.93
40	6.73	40	5.94
45	6.77	43	5.99
51	6.82	50	6.41
55	6.91	55	6.52
60	6.91	62	6.61
65	6.86	65	6.61
70	6.90	70	6.62
76	6.91	75	6.62
80	6.99	80	6.62
90	6.99	90	6.62
100	7.19	100	6.64

C. Preserved Latex.

The normal course of the irregular series observed for fresh field latex is markedly altered by the addition of certain preservative substances. The preservative most widely used in plantation practice is ammonia, but other substances are occasionally employed chief among which are sodium hydroxide and formalin. The various preserved latices were diluted to a rubber content of 4 per cent. since at this dilution comparison of the effect of each preservative substance on coagulation is easily made, and, as with fresh field latex, the transitional stages between the various zones are easily defined. The acid coagulants used were the same for all samples examined.

(a) *Ammonia.*—The samples were prepared by the addition of a solution of ammonia of 0.891 specific gravity to fresh field latex, the concentrations of NH_3 in the various samples ranging from 0.30

to 0.80 per cent. by weight, at the time of preparation. The samples were examined a few days after preparation and at intervals of about one month during a period of storage of ten months. It was found that differences in the period of storage and the quantity of ammonia added did not affect the ranges of hydrogen ion concentration defining the various states of dispersion in the coagulation series. For the sake of brevity the detailed experimental results are not reproduced and the results are summarised in Table XV. Column (1) gives results which are typical of those obtained with all the samples of ammoniated latex. It will be seen that the results are almost the same as those obtained for pure field latex of the same dilution. This applies also to ammoniated latex of higher rubber content although with undiluted latex there is a difference in behaviour after the addition of the coagulant. With undiluted ammoniated latex coagulation is obtained almost immediately after the addition of the acid. The first few drops of acid produces local clotting even when the latex is thoroughly stirred during its addition, and with increasing quantities this clot increases in size until coagulation is complete. With pure latex, however, no such local clotting is observed and several hours must elapse before coagulation is obtained. It may be stated therefore that ammoniated latex is more sensitive than pure latex to acid coagulants.

(b) *Sodium Hydroxide.*—The sample examined was prepared by adding a concentrated solution of sodium hydroxide to field latex to give a latex containing 0.8 per cent. by weight of sodium hydroxide. The interesting feature is that the course of coagulation is affected by the length of the period of storage. When examined within two or three days after the addition of the preservative it was found that coagulation did not take place for any value of pH below 7.0 within a period of 24 hours after the addition of the coagulant. In other words within this specified period the latex does not coagulate whatever its hydrogen ion concentration. As will be seen from Table XV column (2) which gives the results obtained on examination of the sample 2 days after the addition of the preservative, the latex merely flocculates for values of pH at which fresh field latex coagulates, both in the first and in the second coagulation zones. There are two zones of flocculation in place of two zones of coagulation, separated by zones of complete dispersion. Latex within these flocculation zones remains in that state for several days without any evidence of coherent clot formation, but later the floccules gradually cohere and coagulation ensues. This applies also to sodium hydroxide latex of high rubber content. After the addition of the coagulant a coherent coagulum can be obtained only by mechanical kneading of the flocculated mass.

When the same sample of latex treated with sodium hydroxide was examined after a longer period of storage it was found that two zones

TABLE XV.

PRESERVED LATEX.

Dry Rubber Content = 4 per cent.

Ammonia.	*Sodium hydroxide.* Fresh.	*Sodium hydroxide* Long Storage.	*Formalin.*
Complete Dispersion	Complete Dispersion	Complete Dispersion	Complete Dispersion
> 5.30	> 5.69	> 8.00 (Approx.)	> 4.56
Partial Flocculation	Partial Flocculation	Partial Coagulation	Partial Flocculation
5.30 - 5.01	5.69 - 4.78	8.00 - 4.76	4.56 - 4.36
Complete Flocculation	Complete Flocculation	Complete Coagulation	Complete Flocculation
5.01 - 4.92	4.78 - 3.39	4.76 - 3.01	4.36 - 3.41
Coagulation almost complete	Partial Flocculation	Partial Coagulation	Partial Flocculation
4.92 - 4.81	3.39 - 3.00	3.01 - 1.03	3.41 - 3.27
Complete Coagulation	Complete Dispersion	Coagulation almost complete	Complete Dispersion
4.81 - 3.79	3.00 - 1.01	1.03 - 0.63	3.27 - 1.07
Coagulation almost complete	Partial Flocculation	Complete Coagulation	Partial Flocculation
3.79 - 3.51	1.01 - 0.63	< 0.63	1.07 - 0.66
Complete Dispersion	Complete Flocculation		Complete Flocculation
3.51 - 1.02	< 0.63		< 0.66
Partial Coagulation			
1.02 - 0.82			
Complete Coagulation			
< 0.82			

of complete coagulation were obtained as for fresh field latex. Column (3) gives the results for a period of six months' storage. These are typical of those obtained when the latex was examined at intervals of one month after preparation. It is only when freshly prepared that such latex shows abnormal coagulation. Although normal coagulation is restored after longer storage, the latex is very sensitive to acid coagulants, for local clotting takes place immediately after the addition of the acid even when the latex is dilute and at low values of pH. It is thus still more sensitive than ammoniated latex. As will be seen from the table, clotting or partial coagulation commences at a pH well on the alkaline side of neutrality, viz. 8.00, although this value is approximate and had to be obtained colorimetrically by means of indicators, the quinhydrone electrode being inapplicable to solutions with a pH greater than 8.0.

It will also be seen that there is no second liquid zone. Between the range pH 3.01 and 1.03, which defines a state of complete dispersion in the case of pure latex, sodium hydroxide latex partially coagulates, approximately 50 per cent. of the total rubber separating from the dispersion in the form of a coherent clot.

(c) *Formalin.*—Latex preserved by the addition of formalin behaves in much the same way as fresh latex treated with sodium hydroxide. The sample under discussion was prepared by the addition of a solution of formalin to give a concentration of formaldehyde in the latex of 0.4 per cent. by volume and the results given in column (4) of Table XV refer to the examination of the sample after a period of four months' storage. As with freshly prepared latex sodium hydroxide coagulation does not occur within a period of 24 hours when the latex is diluted to a rubber content of 4 per cent. whatever the period of storage. Comparing the ranges of pH in column (4) with those in column (2) it will be seen that there are in both cases two zones of flocculation separated by two zones of complete dispersion, although in the case of latex treated with formalin the first appearance of the flocculation stage is associated with a higher hydrogen ion concentration—pH 4.56 for formalin and 5.69 for sodium hydroxide. Otherwise the behaviour of these two preserved latices is very similar.

(d) *Centrifuged Latex.*—When latex is subjected to centrifugal action, for example in a centrifuge of the de Laval type, separation into two latex fractions takes place. Owing to the difference in the specific gravities of the rubber particles and the dispersion medium, when the bowl of the centrifuge is rotated at a sufficiently high speed the rubber particles being lighter pass to the central axis of the bowl while the serum flows towards the outside walls. The separation is, however, not complete. The cream fraction has

TABLE XVI.

Centrifuged Latex.

Dry Rubber Content=4 per cent.

Cream Latex.	Skim Latex.
Complete Dispersion >5.30	Complete Dispersion >6.50
Partial Coagulation 5.30 — 4.62	Partial Flocculation 6.50 — 5.83
Complete Coagulation 4.62 — 3.31	Coagulation almost complete 5.83 — 5.28
Coagulation almost complete 3.31 — 2.51	Complete Coagulation 5.28 — 3.53
Partial Coagulation 2.51 — 0.73	Complete Dispersion 3.53 — 1.00
Complete Coagulation <0.73	Complete Flocculation 1.00 — 0.70
	Complete Coagulation <0.70

a high rubber content and contains a small proportion of serum substances, while the skim fraction is of relatively low rubber content and contains most of the serum constituents. The samples used in the experiment were obtained by separation in a Sharples super-centrifuge of field latex to which was added 1 per cent. by volume of a solution of ammonia of 0.891 specific gravity. The cream fraction had a dry rubber content of 55.2 per cent. and the skim fraction 10.3 per cent. It may be mentioned that this type of centrifuge was not found to be suitable for continuous work, although in the case under discussion separation was quite successful.

With the object of comparing the course of coagulation for these two fractions each was diluted to a rubber content of 4 per

cent. and examined shortly after preparation. Table XVI which summarises the results obtained shows that there is a considerable difference in behaviour. With cream latex there is no second liquid zone or zone of complete dispersion. Between pH 2.51 and 0.73 slight clotting takes place and about one half of the total rubber present separates as a coherent clot. In behaviour it is very similar to undiluted field latex having a rubber content of 35 per cent. With the skim fraction, however, there are two zones of complete coagulation separated by two zones of complete dispersion, and the first evidences of separation commence at pH 6.50 at which flocculation sets in, whereas with cream latex coagulation commences at a lower value—viz. pH 5.30. Skim latex is peculiar in that there is a flocculation stage in the passage from the second liquid to the second coagulation zone—the range pH 1.00—0.70 defines a condition of complete flocculation. It will be noted that in all the preceding data cited for pure latex, the flocculation stage is associated only with the transition from complete dispersion to the first coagulation zone, and does not appear in the transitional stages between the other zones.

To summarise the experimental work described above an attempt has been made to illustrate graphically in Diagrams I, II, III and IV following a system which accords sufficiently well with the observed facts to bring out differences in the behaviour of the various latices. For this purpose the results have been arranged under three headings (a) Fresh Latex (b) Preserved Latex and (c) Centrifuged Latex. To illustrate the course of the irregular coagulation series for a particular latex the scheme adopted is to divide the abscissa into a scale of pH values and to divide the ordinate into an arbitrarily chosen scale representing the degree of dispersion in the various stages. The number 100 is chosen to represent a state of complete dispersion while zero represents a conditionn of complete coagulation. The scheme does not permit of numerical representation of conditions of the dispersion intermediate between these two extremes, but it does allow of comparison of the ranges of pH values defining the various zones and roughly of the comparative degree of dispersion within these zones.

The effect of dry rubber content on the continuity of the course of coagulation for fresh latex is also summarised in Table XVII compiled from the experimental results recorded under Section A.

TABLE XVII.

FRESH LATEX.

State of Dispersion	Range of pH.			
	D.R.C. = 4 per cent.	D.R.C. = 15 per cent.	D.R.C. = 20 per cent.	D.R.C. = 35 per cent.
Complete Dispersion. -	> 5.30	> 5.54	> 5.80	> 6.24
Partial Flocculation -	5.30 - 5.01	5.54 - 5.24	—	—
Complete Flocculation -	5.01 - 4.91	—	—	—
Partial Coagulation -	—	—	—	6.24 - 4.71
Coagulation almost complete -	4.91 - 4.83	5.24 - 4.78	5.80 - 4.84	—
Complete Coagulation -	4.83 - 3.80	4.78 - 3.51	4.84 - 3.51	4.71 - 3.02
Coagulation almost complete -	3.80 - 3.52	3.51 - 3.01	3.51 - 3.02	3.02 - 0.83
Complete Dispersion -	3.52 - 1.00	3.01 - 1.23	—	—
Partial Coagulation -	1.00 - 0.82	1.23 - 0.73	3.02 - 0.60	—
Complete Coagulation -	< 0.82	< 0.73	< 0.60	< 0.83

CONCLUSIONS.

1. The continuity of the course of coagulation of (a) fresh field latex (b) preserved latex and (c) centrifuged latex by the addition of acids has been studied, and the pH values defining the various zones in the irregular series determined by means of the quinhydrone electrode.

2. In the case of fresh latex diluted to a rubber content of less than 10 per cent. the transition from the first liquid zone to the first coagulation zone is accompanied by a progressive series of changes in the state of the dispersion and is also rather irregular, variations in the pH values defining the transitional stages being found for latex harvested on different days. In most cases on examining the series in the direction of decreasing pH, there is a gradual progression from a state of complete dispersion to complete coagulation, through regions of partial flocculation, complete flocculation and incomplete coagulation, in that order. Generally

the range covered by this transitional stage is from pH 5.30, at which point a separation of the rubber component from the dispersion is first visible at pH 4.87 which marks the beginning of complete coagulation. These values agree fairly closely with those obtained by van Harpen (2).

3. The dry rubber content of fresh field latex exerts a marked influence on the course of the irregular series. With latices varying in rubber content from 4 to 35 per cent., the range of pH values defining the transitional stage between the first liquid and the first coagulation zones increases as the dry rubber content increases. On the other hand, with increasing rubber content the range of values defining a condition of flocculation decreases until with latices of a rubber content higher than approximately 15 per cent. this stage disappears altogether. It was also found that with latices of between 20 and 35 per cent. concentration there is no second zone of complete dispersion. Whereas the dispersion of latices of greater dilution is complete in the range covered by the second liquid zone —approximately pH 3.5 to 1.0—and will remain stable for several days provided the hydrogen ion concentration is kept constant, with latices of greater concentration than 20 per cent. coagulation takes place for approximately the same range of values, the extent of the coagulation depending on the rubber content.

4. Independent of the degree of dilution of fresh field latex the appearance of a flocculation stage is associated only with the transition from the first liquid zone to the first coagulation zone.

5. The irregular series for boiled latex or "B" liquid was studied and confirmation was obtained of observations made by other workers to the effect that such latex does not coagulate until a pH value of 0.80 is reached, and, moreover, that the addition of soaps such as sodium oleate restores normal coagulation in the first zone. This was compared with the effect of the addition of sodium oleate to fresh field latex diluted to the same rubber content as the " B " liquid. Measurement was made of the alteration in pH which occurs in fresh latex heated to various temperatures and allowed to cool to the initial temperature.

6. As regards the course of the irregular series it was found that latex preserved with ammonia behaves in much the same way as fresh field latex. In latex preserved with formalin, however, it was found that if the latex is diluted to a rubber content of less than 10 per cent. coagulation by acid does not occur for any value of pH below 7.0. For approximately the same ranges of values within which fresh latex of the same dilution shows two well marked coagulation zones, there correspond two zones of complete flocculation in the case of formalin preserved latex. Even when the latex is undiluted coagulation by acid takes place only after mechanical kneading of the flocculated mass. The same behaviour was noted for freshly

prepared latex treated with sodium hydroxide. On the other hand, when latex preserved with sodium hydroxide is stored for a month or more, normal coagulation is restored within these two zones although the course of the series is almost continuous, there being no second liquid zone. In such latex also, clot formation by the addition of acids can commence at a pH on the alkaline side of neutrality.

7. A study was also made of latex separated into 'cream' and 'skim' by centrifugal action. It was found that cream latex behaves in a similar manner to latex preserved with sodium hydroxide which has been stored for a month or more, in so far as there is practically no break in the continuity of the series. With the skim fraction on the other hand the irregularity of the series is just as well marked as in the case of fresh field latex. These remarks apply to latices diluted to a rubber content of 4 per cent.

ACKNOWLEDGMENT.

The writer desires here to record his appreciation of the valuable advice of his colleague Dr. C. F. Flint on the assembly of the apparatus used in these investigations.

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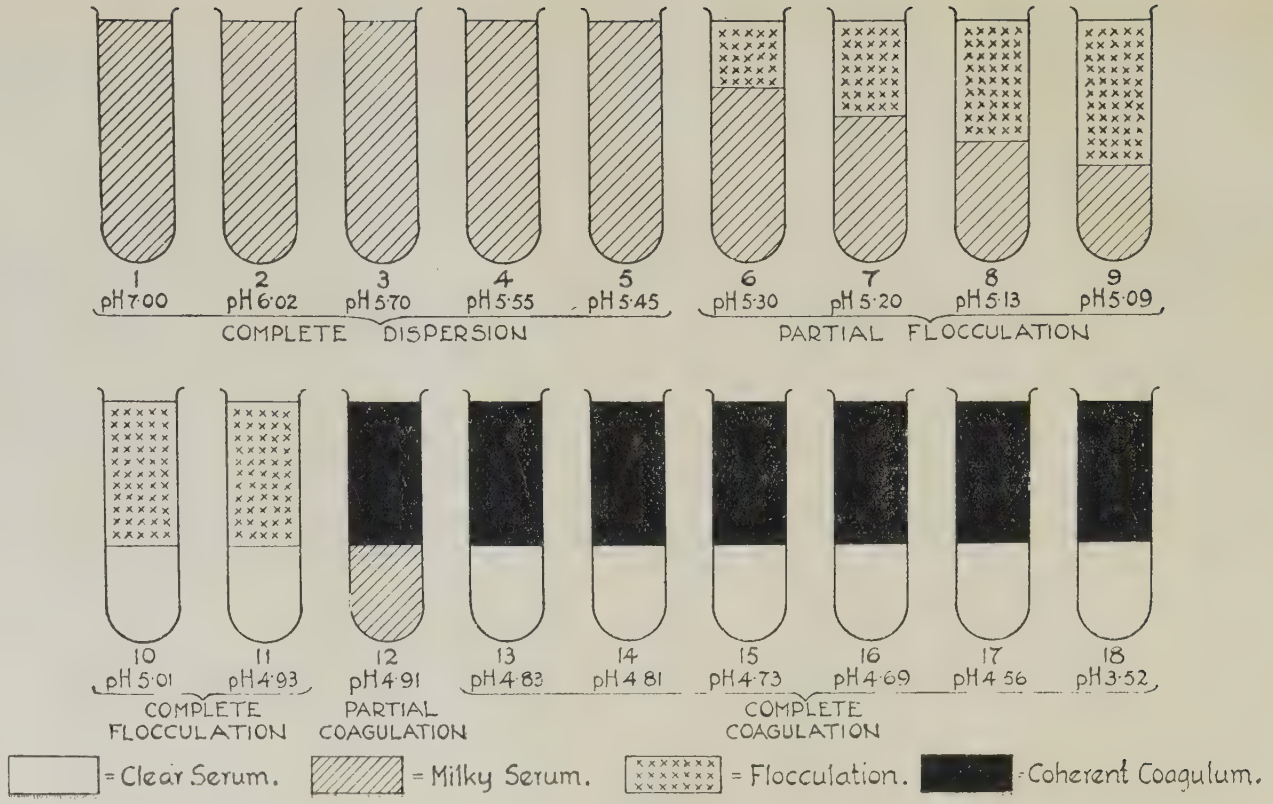
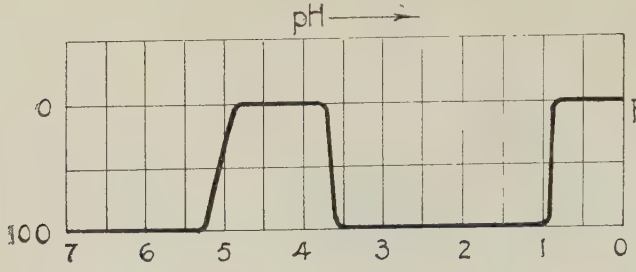
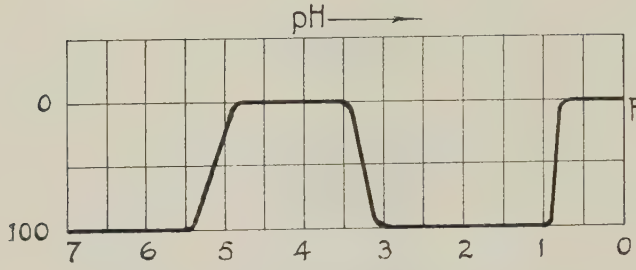

1
pH 7·00
2
pH 6·02
3
pH 5·70
4
pH 5·55
5
pH 5·45
COMPLETE DISPERSION
6
pH 5·30
7
pH 5·20
8
pH 5·13
9
pH 5·09
PARTIAL FLOCCULATION
10
pH 5·01
11
pH 4·93
COMPLETE FLOCCULATION
12
pH 4·91
PARTIAL COAGULATION
13
pH 4·83
14
pH 4·81
15
pH 4·73
16
pH 4·69
17
pH 4·56
18
pH 3·52
COMPLETE COAGULATION
= Clear Serum.
= Milky Serum.
= Flocculation.
= Coherent Coagulum.

DIAGRAM – 1.

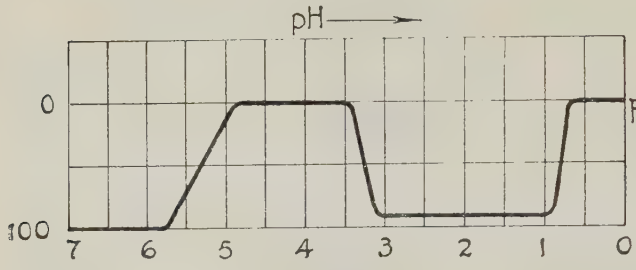
FRESH LATEX.



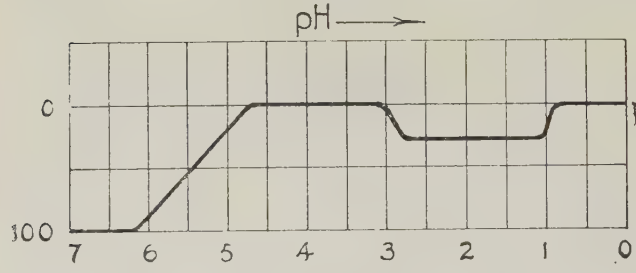
(1) FRESH LATEX. 4% D.R.C.



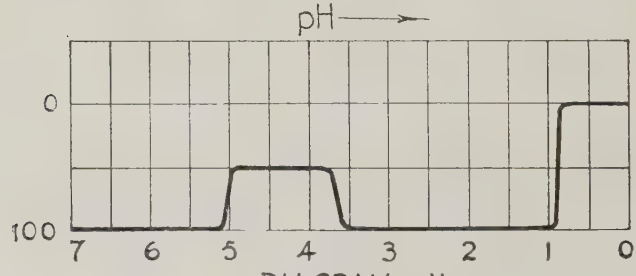
(2) FRESH LATEX. 15% D.R.C.



(3) FRESH LATEX. 20% D.R.C.



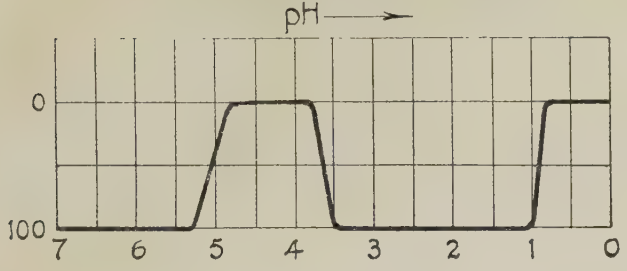
(4) FRESH LATEX. 35% D.R.C.



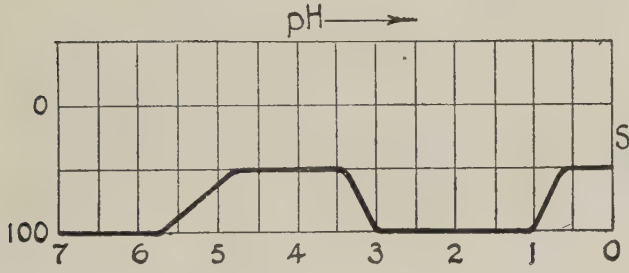
(5) "B" LIQUID. 4% D.R.C.

DIAGRAM—II.

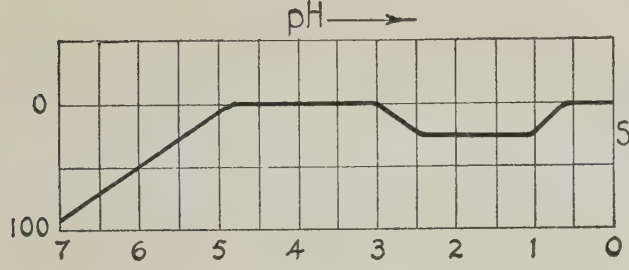
PRESERVED LATEX



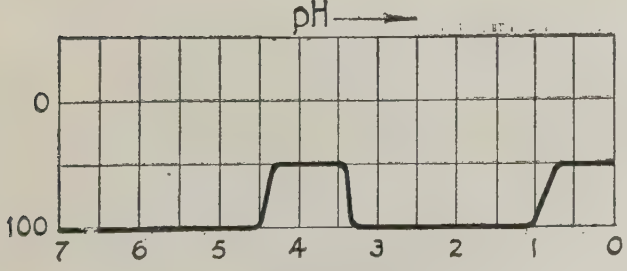
(6)
AMMONIA.
4% D.R.C.



(7)
FRESH
SODIUM HYDROXIDE
4% D.R.C.



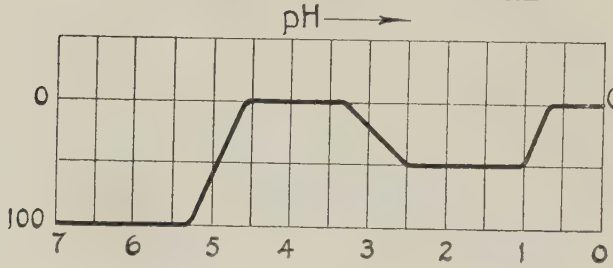
(8)
LONG STORAGE
SODIUM HYDROXIDE
4% D.R.C.



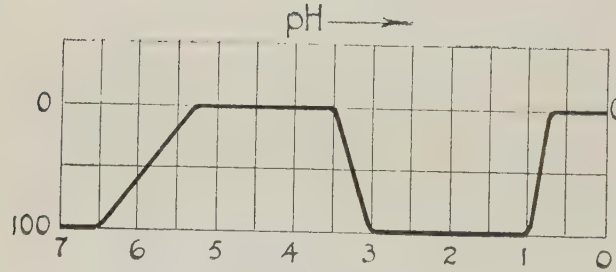
(9)
FORMALIN
4% D.R.C.

DIAGRAM — III.

CENTRIFUGED LATEX.



(10)
CENTRIFUGED LATEX
CREAM.
4% D.R.C.



(11)
CENTRIFUGED LATEX
SKIM.
4% D.R.C.

DIAGRAM— IV.

NOTES

ON

RECENT OBSERVATIONS ON OIDIUM HEVEAE.

BY

F. Beeley.

Following the outbreak of secondary leaf fall early this year, a report on which was published in Quarterly Journal Vol. 2, No. 2, it was thought that observations on the continued activity of the fungus within a field of rubber might prove of value. Accordingly microscopical investigations were made at various times of the year with a view to determining the manner in which the fungus carries over from year to year without the assistance of a known resting spore stage. As a result of these investigations the following facts have emerged:—

1. The conidial (powdery mildew) stage of the fungus occurs on the inflorescence of the rubber tree at all times during the year.
2. Flowers developed from the terminal buds of leading branches of the tree were almost invariably infected, and within a few days of the bud bursting the very active sporulating fungus may be found in abundance on the flower buds and and on the floret stalks.
3. Flowers developed from lateral buds appeared to be infected later in their development, possibly from spores blown from the heavily infected terminal flowers.
4. Stems and young leaves on known infected trees did not develop the disease during the months June—September.
5. Young leaves developed at the end of September and in October were found to have small patches of the active fungus on the midrib.
6. At all times during the period under observation the field contained trees which were in flower.
7. Very few seeds have set, and of these some are light in weight. This, however, may be due to drought and not to disease.
8. Living germinating spores of *Oidium Heveae* have been found in the axils of mature leaves, in the bud scales of terminal buds and on seed pods.
9. A terminal bud just beginning to open was found to be infected with the active fungus. It would appear, therefore,

that the delicate tissues of such buds serve to carry over the fungus during inclement weather or when new young leaves or flowers are not present.

10. Following heavy rain the conidiophores and spores disappear, but after a few days' dry weather fresh conidiophores are developed from the creeping surface mycelium.

11. Young known infected inflorescences when brought into the laboratory (temperature 25°-32°C) developed chains of 2-4 spores within two days while, in a cold chamber, (temperature 11°-14°C) rapid growth with production of numerous conidiophores bearing chains of 3-7 spores has been obtained on living Hevea flowers in the same period of time.

It would appear, therefore, that optimum growth for *Oidium Heveae* takes place at temperatures considerably lower than those normally experienced in tropical countries.

In conclusion it may be said that the weather conditions during the past year have been favourable to the growth of the fungus on certain parts of the tree, particularly the flowers, throughout the whole of the year, while young leaves appear to be susceptible to the disease during a part of the year only. It is evident, however, that, in the manner of growth of the rubber tree in plantations, suitable tissues whether leaf, flower or bud are always available to maintain a continued life of the fungus in its mycelial and conidial stages.

SILT-PITTING ON ESTATES IN RELATION TO MOSQUITO BREEDING & MALARIA.

A REPORT BY THE MALARIA ADVISORY BOARD IN CONJUNCTION WITH THE DEPARTMENT OF AGRICULTURE AND THE RUBBER RESEARCH INSTITUTE.

Since silt-pitting became a widespread practice in rubber estates in the Malay Peninsula, the larvae of dangerous anophelines, notably of *Anopheles maculatus*, have been found by many observers and on many occasions in water standing in silt-pits both on hillsides and on comparatively flat land. The tendency for *Anopheles maculatus* to breed in such pits undoubtedly becomes greater where other natural waters are regularly and efficiently oiled, the anopheline being thus driven to breed in what might not naturally be selected as a breeding place. It may, therefore, be accepted that silt-pits and other trenches which hold water for sufficiently long intervals, and are situated within a radius of some forty chains from dwellings, are a menace to health. This state of affairs has led in some cases to an apparent conflict between the agricultural requirements of silt-pitting in rubber, and the medical requirements of anti-malarial work; but the supposed antagonism becomes the less pronounced the more closely it is examined.

The main aim of all earthwork systems on undulating or hilly land is to stop surface wash of water during heavy rainfall, and to induce the water to percolate naturally through the soil. In old-planted rubber this is usually best attained by silt-pitting with bunds.

There is no necessity for water to be held in catchment pits for any length of time; indeed, it may be said that if the water remains for days at a time it is best from an agricultural, as well as from a medical point of view, that means should be taken for its quicker removal. If, therefore, the rate of percolation into the soil cannot be sufficiently improved, the measures taken should be made to simulate the normal drainage of flat land. Here stops are dispensed with, and the trenches form a continuous system, so that water can be readily carried off. On sloping land of such a heavy character the conditions to be aimed at would cause the contour drains to run to a common outlet, and with a view to preventing wash during heavy rain artificial stops of a pervious nature may be erected (rubble, brushwood, etc.) A system of this kind would let the water trickle

away without permitting sudden rushes. Drainage systems on this principle for such special cases have already been reported as functioning successfully in Malaya.

Where the soil tends to be impermeable, however, it is doubtful whether any such steps can prove entirely adequate from a health point of view, since small puddles will always tend to remain at the bottom of the trenches however well they may be finished. These cases of great resistance to water penetration must be accepted as expensive and difficult both for anti-malarial work and for soil cultivation. There is every reason that preventive measures against malaria (such as oiling) should be accepted as a standard practice in hill drains or pits under these circumstances just as they are for other drains in flat land. The work will be more of a seasonal nature than on flat land.

To repeat, since silt-pits or drains are necessary in old rubber, measures should be adopted within forty chains of dwellings for the prevention of anopheline mosquito breeding in any water retained in such pits or drains.

Such possible measures are:—

(a) Measures to prevent retention of excess water. Although pits are used to conserve water in most cases, other cases arise in which removal by drainage is required just as on flat land.

(b) The use of larvicides, such as a suitable anti-malarial oil mixture, applied in the usual way by spraying. The easiest method, however, for these particular conditions, is to apply liquid fuel (Diesel oil), with a very small mop. Oil applications on such stagnant water will be safe if done only once a fortnight. Such oiling of all water retained in pits in a residential area is being done at present by a number of estates as part of the regular anti-malarial work. Alternatively the pits may be dusted with a dusting mixture containing Paris Green, which would need to be applied once in every five or seven days. Experience is not yet sufficient to compare the cumulative effects of such treatments upon the soil conditions.

(c) In flat land, trenches should be continuous, without stops. Small depressions on the land which retain puddles of water will be limited in number, and may be filled with loose soil without harm to the general agricultural system as regards rain percolation. In flat land, deep water drains are advisable connected with the natural drainage system of the area, and oiled or otherwise treated anti-malarially as part of that system.

Drainage in New Clearings. In residential areas it is preferable to make bunds. On hilly land these should be made in connection with terraces. The bunds whether in connection with terraces or not, may be made by drawing together the soil instead of digging pits. Such systems should always be adopted in anti-malarial areas in new clearings, in place of pitting or digging trenches, unless such special soil conditions exist as would make pitting indispensable. These systems may be chosen both on anti-malarial grounds and on their own merits as regards permanence and efficiency.

NOTICES.

Budding Operators.

With reference to the terms for the loan to estates of budding coolies from the Experiment Station, published in this Journal Vol. 2 No. 2, 1930; page 108, the following should be added:—

> "A charge of 2 cents per successful budding is made, this being a bonus paid to the coolies. The account of success obtained to be made by the estate on final inspection and sent to the Manager, Experiment Station, Rubber Research Institute of Malaya, Sungei Buloh, Selangor."

Information Cards.

A set of Information Cards, dealing with various phases of rubber estate factory practice and defects in raw rubber has been published. Each card deals with a specific problem and the set already published comprises fifteen cards.

These cards may be obtained on application to the Director of the Institute.

A suitable loose leaf stiff cover or holder has also been made to contain the cards. If the cover as well as the cards are required a charge of 35 cents is made, which sum should be forwarded with applications.

EDITORIAL.

Information Cards.

In view of the fact that a number of estate managers do not yet appear to be aware of the issue of these cards, which deal with (a) various phases in the preparation of raw rubber, (b) common defects in raw rubber and remedies for such defects, it appears desirable to draw attention again to these Cards.

Each card deals with one particular problem, e.g. coagulation, sodium sulphite, moulds in rubber, spot disease, etc.

The cards are of a convenient pocket size for use in the factory and are contained in a suitable loose leaf stiff cover, so that additional cards when published can be easily inserted.

Sixteen cards have already been issued, in addition to several coloured illustrations of certain defects. When a new card is issued, a copy is sent to those who are on our mailing list who have previously received the original set.

These cards serve a useful purpose by dealing in a concise manner with factory procedure and defects in raw rubber. It is hoped to extend their use to other phases of estate practice, so that planters may be in possession of a convenient and ready reference relating to a number of the common problems met with in such practice.

These cards are supplementary to the more detailed articles on such problems, published in the Journal or in the Manuals.

The cards are issued free on application, but a charge of 35 cents (Straits currency) is made for the cover.

Disinfection of Budwood.

The problem of the disinfection of budwood or budded stumps either exported from or imported into this country may become of some importance.

It is already suspected that the occurrence of Phytophthora on certain budded rubber plants in Ceylon is due to the importation of infected material.

Reports of budded stumps, infected with certain root diseases, imported into Indo-China have also been published.

Although all material despatched from the Netherlands East Indies and from Malaya is subjected to inspection before export, no methods of disinfection have yet been applied. It must be borne in mind, however, that the importation of material infected with disease is always possible. As far as Malaya is concerned the fungus diseases which are present on rubber plantations occur in all the most important rubber producing countries in the Eastern tropics, although some are more virulent and widespread in one or other country.

In view, however, of regulations for disinfection which may be introduced in any country which may be exporting or importing such material, it was considered desirable to initiate experimental work on the treatment of budwood with a number of suitable fungicides.

This journal contains an article by Mr. R. P. N. Napper of the Pathological Division describing in particular the effects of these fungicides on the viability of the buds.

Although the investigations are admittedly incomplete they indicate that a number of these fungicides can be used, without seriously affecting the viability of the buds. The treatments recommended are also satisfactory from the point of view of their fungicidal effect. Since the investigations, however, were carried out on budwood of only one clone, it is desirable to extend them to other budwood, the buds of which may be more susceptible to any deleterious effects caused by the treatment.

With regard to the die-back of the ends of the budwood, it is considered that this is due to the temperature of the melted wax used and not to the wax *per se*. It was not possible to control this temperature accurately. It may be found that the treatment of the cut ends with the asphalt-cum-kerosene mixture recommended for the sealing of wounds will prove more satisfactory.

Spraying Experiments on Young Rubber Plants.

Young rubber plants, especially in nurseries, are frequently attacked by various minor leaf diseases and by mites. In many cases, the severity of the attack is not sufficient to warrant treatment while in certain circumstances, which appear to depend largely on climatic conditions, spraying with suitable mixtures having both a fungicidal and insecticidal value may be necessary. The article in this journal by Mr. F. Beeley of the Pathological Division describes the results of experimental spraying of young rubber plants with various well known fungicidal and insecticidal mixtures which have been found to be satisfactory for the purpose.

Sheeting Batteries.

It is perhaps surprising at this period in the history of rubber estate factories that the question of the most suitable size of rolls for sheeting machines, the depth of coagulating tanks or width of coagulating pans, together with the optimum speed of rolls to obtain maximum output has not received more attention from the engineering firms who are concerned with the manufacture of such machinery and plant.

It is obvious that, in particular, the width of the coagulum has an important bearing on the quantity that can be passed through the sheeting machines in unit time.

The width, however, is limited by the capacity of the operators for handling the material, the rather tearable nature of the soft coagulum and the width of rolls that can be used in different types of machines. If the rubber is packed in the wooden cases used at present the width of the final dry sheet is limited to about 18½ inches. The problem is complicated in some respects, by the fact that the softness of the coagulum to be rolled varies considerably and is dependent on a number of factors, such as the period elapsing between coagulation and machining, the concentration of the latex, the amount of coagulant used and possibly variations in the nature of the latex.

During recent years, it has been realised that light sheeting batteries, consisting preferably of three smooth-roll machines and one marking-roll machine, which can be driven by a 2½ H.P. petrol engine, a 5 H.P. oil engine or an electric motor of similar low power capacity, are entirely suitable and more economical to run than the heavy machines formerly in use. Even when large smooth rolls, necessary for "finishing" thin crepe, are available in estate factories which prepare both smoked sheet and thin crepe rubber, it is frequently more economical to install a battery of light machines for the preparation of sheet rubber.

As a result of a questionnaire circulated to estates over 200 replies have been received from which it has been possible to analyse the outputs and to ascertain the reasons for the large variations on different estates and thus to commence an investigation with a view to effecting improvements.

Although much remains to be done, it is satisfactory to record that the high output of over 1200 lbs. of dry rubber per hour has now been attained with a battery of three light smooth roll machines and one marking roll machine.

This represents a notable advance on normal practice and will be of great value to estates which are contemplating the erection of new factories or the installation of new sheeting machines. It represents a considerable saving in both capital and running costs.

One manager estimates that he is saving $200/- per month in his factory on account of the increased output per battery.

Details of the results obtained from the questionnaire and of the subsequent investigations made with the object of accelerating output are contained in an article by Mr. R. O. Bishop and Dr. E. Rhodes published in this journal.

Manganese in Raw Rubber.

An article by Mr. R. O. Bishop and Mr. K. C. Sekar in this journal describes some preliminary investigations in relation to the effect of potassium permanganate on raw rubber.

Although small quantities of manganese are present in various parts of most plants and plant products, it has been known for some time that certain manganese compounds when added in comparatively small quantities to raw rubber have a deleterious effect, especially when the rubber is stored. Such rubber ages badly. The effect, although not so pronounced, is similar to the effect produced by soluble copper salts which cause an oxidation of the caoutchouc by absorption and combination of oxygen from the air. The rubber at first becomes soft and tacky and may even flow but eventually is converted into a brittle resin.

Bruni and other workers have previously been able to associate tackiness in certain grades of rubber with the presence of excess of manganese.

Potassium permanganate in dilute solution is known to possess only a weak fungicidal action, especially in the presence of much organic matter, so that its use as a fungicide for the treatment of latex and raw rubber is not recommended.

Until further investigations have been conducted, the use of this substance either as a fungicide or for darkening rubber to produce an imitation smoked sheet, whether used alone or in combination with other substances must be viewed with suspicion. It is interesting to note, however, that recent investigations in relation to the effect of anti-oxidants on raw rubber containing copper, manganese or other metallic compounds which oxidise the rubber and reduce the ageing qualities of the vulcanised product have shown that certain anti-oxidants are effective in reducing or eliminating this oxidation.

Further investigation, however, is essential before definite conclusions are obtained as to the suitability of mixtures which contain potassium permanganate for application in the preparation of raw rubber, even when such mixtures contain a substance which is known to be an anti-oxidant.

THE EFFECTS OF CERTAIN FUNGICIDES ON THE VIABILITY OF HEVEA BUDS.

BY

R. P. N. NAPPER.

INTRODUCTION.

In view of the existing legislation with regard to plant quarantine measures in relation to the rubber tree in Malaya, the following experiment was planned to investigate the effects of certain common fungicides on the viability of buds. There are two possible methods of complying with such legislation, viz. disinfection in the country of origin, and disinfection at the port of entry. It was decided that this experiment should deal with the former possibility.

The methods of treatment used were such as would be compatible with normal estate practice, and the fungicides (with one exception) were well known mixtures or proprietary preparations familiar to estate managers and easily obtainable in this country.

EXPERIMENTAL DETAILS.

On the morning of each of seven consecutive week days, budwood of one clone, AVROS 50, was cut from Block 4 nursery at the Experiment Station, Sungei Buloh, waxed, treated, packed in a box, and stored in a cool dry place. At an interval of seven days after packing, to represent a period of transportation from one country to another, each box was returned to the nursery where it was opened, notes were made on the condition of the budsticks, the sticks were stripped, and 100 buddings were made from each treatment. When budding was finished the stripped sticks were rolled in sacking, repacked in the box, and taken to the laboratory for further examination. Sixteen days after budding each day's task was examined and a record made of the percentage number of successful buddings obtained from each treatment, while after a further interval of 23 days a second and final inspection was made.

With one exception the treatments consisted in immersing the budwood in liquid, water miscible disinfectants, in a small wooden tank ($3\frac{1}{2}$ ft. × 6 ins. × 6 ins. holding 5 gallons of liquid), waxed inside, and provided with false cross partitions at either end. These partitions stopped short of the bottom of the tank so that the ends of the budsticks could be inserted below them and the surface of the sticks kept completely immersed. One partition was movable.

Clone AVROS 50 yields 20—25 buds per yard and, in order to obtain at least 120 buds treated with the same concentration of fungicide, 6 yards of budwood were used for each treatment. Of these, 3 yards were washed in water as soon as the sticks were taken from the tank, 60 buds were stripped, and 50 buddings were made from each sub-treatment.

On each day 36 yards of budwood were used, comprising 24 yards of treated material and 12 yards of control, of which 6 yards were washed with water only while the remainder were not treated in any way. As each treatment was completed, and without allowing the budwood to dry, the sticks were rolled individually in damp sterilised coconut fibre and placed in layers in a packing case $3\frac{1}{2}$ ft. × 1 ft. × 1 ft. each treatment occupying one layer. The layers were separated by a thickness of fibre and the sticks were prevented from chafing by tightly packing the spaces at the ends and sides of the box. The cases were of the correct size to accommodate 36 yards of budwood and the packing was excellently done.

The treatments and sub-treatments used are given in Table I:—

TABLE I.

Box No.	Treatment No.	Fungicide.	Strength per cent.	Time of treatment in minutes	After treatment.
No. 1.	C. U.	Control			None
	C. W.	Control			Washed
	I. W.	Copper Sulphate	2	2	Washed
	I. U.	,, ,,	,,	,,	None
	II. W.	,, ,,	,,	5	Washed
	II. U.	,, ,,	,,	,,	None
	III. W.	,, ,,	5	2	Washed
	III. U.	,, ,,	,,	,,	None
	IV. W.	,, ,,	,,	5	Washed
	IV. U.	,, ,,	,,	,,	None
No. 2.	C. U.	Control			None
	C. W.	Control			Washed

TABLE I.—(contd.)

Box No.	Treatment No.	Fungicide.	Strength per cent.	Time of treatment in minutes.	After treatment.
	VII. W.	Solbar	1	2	Washed
	VII. U.	,,	,,	,,	None
	VIII. W.	,,	,,	5	Washed
	VIII. U.	,,	,,	,,	None
	IX. W.	,,	2	2	Washed
	IX. U.	,,	,,	,,	None
	X. W.	,,	,,	5	Washed
	X. U.	,,	,,	,,	None
No. 3.	C. U.	Control			None.
	C. W.	Control			Washed
	XI. W.	Lime-sulphur	1	2	Washed.
	XI. U.	,, ,,	,,	,,	None.
	XII. W.	,, ,,	,,	5	Washed.
	XII. U.	,, ,,	,,	,,	None.
	XIII. W.	,, ,,	5	2	Washed.
	XIII. U.	,, ,,	,,	,,	None.
	XIV. W.	,, ,,	,,	5	Washed.
	XV. U.	,, ,,	,,	,,	None.
No. 4.	C. U	Control.			None.
	C. W.	Control.			Washed
	V. W.	Sulfinette.	2	2	Washed.
	V. U.	,,	,,	,,	None.
	VI. W.	,,	,,	5	Washed.

TABLE I.—(contd.)

Box No.	Treatment No.	Fungicide.	Strength per cent.	Time of treatment in minutes	After treatment.
	VI. U.	,,	,,	,,	None.
	XV. W.	Liver of sulphur.	1	2	Washed.
	XV. U.	,,	,,	,,	None.
	XVI. W.	,,	,,	5	Washed.
	XVI. U	,,	,,	,,	None.
No. 5.	C. U.	Control.			None.
	C. W.	Control.			Washed
	XVII. W.	Ammonium polysulphide.	1	2	Washed.
	XVII. U.	,,	,,	,,	None.
	XVIII. W.	,,	,,	5	Washed.
	XVIII. U.	,,	,,	,,	None.
	XIX. W.	,,	,,	2	Washed.
	XIX. U.	,,	,,	,,	None.
	XX. W.	,,	,,	5	Washed.
	XX. U.	,,	,,	,,	None.
No. 6.	C. U.	Control.			None.
	C. W.	Control.			Washed
	XXIII. W.	Uspulun.	5	2	Washed.
	XXIII. U.	,,	,,	,,	None.
	XXIV. W.	,,	,,	5	Washed.
	XXIV. U.	,,	,,	,,	None.
	XXV. W.		1	2	Washed.

TABLE I.—(contd.)

Box No.	Treatment	Fungicide.	Strength per cent.	Time of treatment in minutes	After treatment.
	XXV. U.	„	„	„	None.
	XVI. W.	„	„	5	Washed.
	XVI. U.	„	„	„	None.
No. 7.	C.	Control packed in normal fibre.			
	XXI.	½ lb. Sulphur dust included in the packing fibre.			
	XXII.	1 lb. „ „ „ „ „ „ „			

The budding was performed by a gang of six Tamil budders, and one sub-treatment was dealt with at a time. The sticks were stripped by the three most experienced budders, and the bud slips distributed between them and the others in proportion to their individual rates of working. Each budder performed a constant proportion of the total number of buddings from each sub-treatment, and thereby the personal factor was eliminated from the results.

In the following sections a sub-treatment will be referred to as a "treatment".

Difficulties Encountered.

The experiment, as planned, should have given a set of results strictly comparable one with another through the controls, but in practice several difficulties arose which affect the significance of the results obtained.

In the first place the amount of budwood necessary (234 yards of one clone) was so large that the Botanical Division could not provide all brown wood; some of the sticks were too young, and at least half were in the green condition. This gave rise to two difficulties, (1) it was impossible to include budwood with the same range of maturity in each treatment, and (2), the green wood sprouted to a considerable extent after defoliation, and the sprouted buds were frequently damaged during cutting and transportation to the packing shed (neither of which operations could be personally supervised) and also during treatment, in spite of the utmost care. These injuries provided entrance for fungi, and also exposed the delicate inner tissues of the cortex to the action of the disinfectants, both of which factors may easily have led to the death of neighbouring buds.

The magnitude of the experiment gave rise to a further difficulty, for it necessitated the budding of 600 seedlings per day, i.e. 100 each per budder per day. Budding was not straightforward, as it had to be suspended after every 50 buds had been put on, while the sticks of the next treatment were stripped. The day's task could not be completed under 5 hours, and since at that period of the year rain commenced to fall as early at 12.30 p.m. nearly every day, budding had to commence before 7.30 a.m. At this hour, however, the nursery was rarely dry and on two mornings in particular (December 8th and 9th) the stems did not dry out before 8.30 a.m. A wet stem and wet canopy during budding is the source of many disadvantages, for drops of water carrying all sorts of undesirable organisms cannot be prevented from getting under the tongue of bark, while waxed cloths will not adhere to a wet stem, and firm binding is difficult to achieve.

The controls were budded first each day, so that any drop in successes due to early morning budding might reduce, rather than exaggerate, the significance of the differences between the results from the treated sticks and from the controls. The abnormally low results obtained from the controls on the two days mentioned above (as compared with controls on other days) may well have been due to this factor. It is notable that on each of the following days, the 4th, 5th, 6th and 10th of December, the percentage successes obtained from the controls was exceeded by that obtained from one or more of the treatments budded later in the morning. Although in a perfect experiment this would suggest that disinfection with certain concentrations of fungicides has a beneficial antiseptic action on the buds, the greater success is probably due solely to the fact that the controls were budded before the stocks were sufficiently dry.

A fact which became obvious when the boxes of treated material were opened, was that the wax used (Entwas) had too high a melting point, and that in every case some of the die-back at the ends of the budsticks could be attributed to injuries during waxing. Unfortunately the extent of this injury could not be estimated, for inspection of the controls showed that it varied considerably. It was much more severe on green sticks and apparently small changes in temperature of the wax had considerable influence on its lethal effect. Such small changes could not be avoided, as the wax had to be heated in an open pan over a wood fire and it was impossible to keep it at a constant temperature.

Yet another source of error lay in the fact that the stocks on which the buddings were performed were not uniform. It would of course have been impossible in a small section of an ordinary nursery to find 4,000 buddable stocks in the same state of development. On the whole the stocks were in excellent condition but some of the beds lay in areas known to be infected with *Fomes lignosus*. In these beds growth was backward and very irregular, and this fact

may have contributed considerably towards the low percentage successes recorded in many of them.

Another difficulty arose on the 3rd Dec. when both the budding of the original Box No. I treated with copper sulphate solution on Nov. 26th, and the treatment of Box No. 7, were due to take place. Budding was to have been carried out on Pilmoor Estate, by kind permission of the Manager, and was actually started there on the morning in question. The treatment of Box No. 7 had therefore to be left in the hands of the subordinate staff on the Experiment Station, with, as is shown later, unsatisfactory results. (For various reasons budding at Pilmoor Estate had to be abandoned; Box No. 1 was repeated after Box No. 7, and all subsequent budding was done at the Experiment Station, Sungei Buloh, on stocks provided by the Botanical Division in Block 4 nursery).

The results obtained, which are given below, should be interpreted in the light of these observations.

Results.

The condition of the budwood at the time of budding was judged from its general appearance, and from the distance to which the bark had died back at the upper ends of the sticks. As would be expected there was always more die-back at the upper ends than at the lower ends. The cambium in all cases had died back beyond the limit of dead bark, but in the field the amount of bark die-back was easier to record than the amount of cambium die-back, as it could be determined readily by cutting a shaving of bark from the end of a stick and determining the point at which the latex flowed freely.

No buds were stripped from the portions of the sticks bearing dead bark. The budders were left to choose the strippable buds themselves, and as they were interested in the number of successes, they were very careful to select only apparently healthy buds.

On each day, as the buds were stripped, the sticks were tied together in lots according to treatment, placed in a sack, repacked in the same box, and taken to the laboratory, where they were examined on the following day by Mr. Beeley, who has kindly furnished further information with regard to the condition of the budwood at the time of budding. The observations made are too detailed to be given at length, but when considered in conjunction with the observations made at the time of stripping, and with the budding results subsequently obtained, they lead to the following conclusions.

None of the treatments used caused visible disorganisation of the bud tissues at the time of budding, except those in Box No. 1, where all treatments stronger than the soaking in 2 per cent. solution of copper sulphate for 2 minutes produced rotting of the buds to a greater or less extent. None of the fungicides appeared to have

penetrated the cuticle of green sticks during the interval between treatment and budding, but copper sulphate rendered the cuticle dry and brittle. In the majority of cases a mottling of the surface of the green sticks was noted which was not caused by fungus attack, but was probably due to some reaction between the disinfectant and the substances of the cuticle.

The fungicide which appeared to cause least superficial damage to the budwood was ammonium polysulphide, and the surfaces of the green sticks treated with this disinfectant were in a bright green, healthy, unmottled condition. The fungicide which caused by far the most serious damage to the budwood was copper sulphate and, even at the weakest concentration, death of some buds occurred. It was noticed that penetration took place around the base of the buds, and that in some cases a still healthy bud could be found isolated in a patch of dying cortex. In the budwood treated with copper sulphate the sticks died back from the buds as well as from the waxed ends, but in all other cases die-back of sticks appeared to proceed via the cambium from the waxed ends.

Observations on the age of the budwood made at the same time explained some apparent anomalies in the results from the subsequent buddings. It is known that, when budwood is very pithy and the buds are prominent and leave a large protuberance on the wood after stripping, the buds are immature, and the successes obtained from such budwood will be low. Mr. Beeley made a special note when reporting on treatments XIX.U. & I.U. to the effect that the budwood in each case was in this condition, and this probably accounts for the abnormally low number of successes obtained from each of these treatments compared with the treatments described above and below them in their respective tables. These results were the most strikingly anomalous and could not be explained away as due entirely, either to the treatment, or to abnormal injury during waxing.

After allowing the stripped sticks to stand for a few days many kinds of mould appeared on them, especially species of Diplodia, Gloeosporium, and Fusarium. The sticks from the copper sulphate treatments were actually mouldy at the ends when stripped for budding, and in every case it was the sticks which had been most injured, either by waxing or subsequent disinfection, that developed moulds most rapidly, irrespective of treatment. There was a suggestion, however, that the controls, and especially the washed controls, developed moulds more quickly than did treated material in apparently the same condition, but otherwise the fungicidal action of the various disinfectants seemed to have disappeared during the interval between treatment and budding.

As this paper was written before the second inspection of buddings was made, only the results of the first inspection are discussed below. The numerical results of the second inspection are, however,

given in the following tables, and are discussed collectively in a final paragraph.

Box No. 1, Copper Sulphate.

This box was originally packed on November 26th, to be budded on December 3rd, but for various reasons had to be abandoned. It was repeated at the end of the experiment, after the treatment of Box No. 7.

TABLE II.

Treatment No.	Condition of Budwood at time of Budding.	Successes 1st inspection per cent.	Successes 2nd inspection per cent.
C. U.	Good, slight die-back of bark at the ends -	97	85
C. W.	,, ,, ,, ,, ,, ,, ,,	95	83
VII. W.	One green stick died back 8 ins ; remainder good -	81 (×)	74
VII. U.	Good ; 1—2 ins. of die back -	76 (×)	74
VIII. W.	One green stick died back 4 ins ; remainder good -	98	80
VIII. U.	One stick died back 4 ins ; remainder good -	90	84
IX. W.	Youngest stick died back 4 ins ; remainder good -	90	80
IX. U.	Green stick died back 6 ins ; remainder fairly good -	96	82
X. W.	Excellent ; $\frac{1}{2}$ - 1 in. die-back only -	98	96
X. U.	,, ,, ,, ,,	92	86

Box No. 2, Solbar.

Treated, November 27th, 1930. Budded, December 4th, 1930. Opened and inspected, December 20th, 1930. Second inspection, January 12th, 1931.

The results marked with a cross must be explained first. Treatments VII. U. and VII. W., in that order, were the last to be budded, and while the budding of VII. U. was in progress a drizzle of rain started. It was hoped the rain would cease, but after putting on a few buds from VII. W. a heavy storm occurred which suspended budding operations until late in the afternoon. It is interesting to note that the successes obtained from VII. U., which was budded actually

during the rain (c.f. remarks on this subject in the previous section), are below those obtained in VII. W., which was not completed until after 6 p.m. when the bud slips had been cut and exposed for six hours.

There are no significant differences between the rest of the results, except perhaps between X.W. and X.U. The budwood in both instances was in excellent condition and hardly affected by the hot wax, so that the results may with some justification be considered to be due to the treatments alone.

The conclusion reached from this set of treatments is that Solbar does not injure buds even in as high a concentration as 2 per cent. for 5 minutes as long as the sticks are washed (at this concentration) immediately after removal from the dipping tank. If left unwashed, the fungicide at this strength may have a deleterious effect on the buds.

TABLE III.

Box No. 3, Lime-sulphur (B).

Treated, November 28th, 1930. Budded, December 5th, 1930. Opened and inspected, December 21st, 1930. Second inspection, January 13th, 1931.

Treatment No.	Condition of Budwood at time of Budding.	Successes 1st inspection per cent.	Successes 2nd inspection per cent.
C. U.	3 sticks good ; the remainder died back up to 6 ins. -	93	85
C. W.	Good ; 2 - 4 ins. die-back -	99	95
XI. W.	Excellent ; ½ - 1 in. die-back -	100	90
XI. U.	Very good, except on one stick with 6 ins. of die-back -	98	94
XII. W.	Very good ; 1 in. die-back -	100	92
XII. U.	Excellent ; ½ - 1 in. die-back -	100	98
XIII. W.	Poor ; up to 6 ins. die-back -	92	90
XIII. U.	Good ; 2 - 3 ins. die-back -	96	96
XIV. W.	Fair ; 4 - 6 ins. die-back -	90	82
XIV. U.	Good ; except on two sticks with 4 ins. die-back -	82	78

These results, although perhaps not statistically significant, certainly suggest very strongly that the mixture of Lime-sulphur at

1 per cent. concentration of polysulphide sulphur for 2 minutes and 5 minutes has no effect on the viability of the buds, but that when a 5 per cent. concentration is substituted it causes increasing mortality of the buds.

Two figures in the table require some explanation. The unwashed control shows a considerably lower percentage success than some of the treatments, and this is probably due to the two facts, that it was budded before the nursery was sufficiently dry, and that three of the sticks had been severely injured during waxing, or had not been properly waxed. They were the youngest and greenest sticks.

Treatment XIII. W. also gave a lower number of successes than was obtained from both the immediately preceeding and succeeding treatments, but here again the condition of the budwood was poor and the die-back of the bark may easily have led to the death of the buds stripped near the ends.

TABLE IV.

Box No. 4, Sulfinette & Liver of Sulphur.

Treated, November 29th, 1930. Budded, December 6th, 1930. Opened and inspected, December 22nd, 1930. Second inspection, January 14th, 1931.

Treatment No.	Condition of Budwood at time of Budding.	Successes 1st inspection per cent.	Successes 2nd inspection per cent.
C. U.	Good, except on two sticks with 4 ins. die-back.	95	78
C. W.	Poor ; one stick dead to 8 ins, the others to 6 ins.	85	78
V. W.	Fair; one stick dead to 6 ins, another to 4 ins.	86	84
V. U.	Fairly good ; 4 ins. die-back.	94	90
VI. W.	Good, except one stick with 4 ins. die-back.	96	90
VI. U.	Fairly good ; two sticks with 4 ins. die-back.	96	94
XV. W.	Fairly good ; one stick with 6 ins. die-back.	88	80
XV. U.	Fairly good ; two sticks with 4 ins. die-back.	94	82
XVI. W.	Very good ; 1 in. die-back.	100	92
XVI. U.	Good ; 1 - 2 ins. die-back.	90	80

The differences between these results are not significant, and all that can be determined from them is that none of the treatments had any notable deleterious effect on the budwood. The figures for the last two treatments, XVI.W. and XVI.U., may be exceptions, as in each case the budwood was in better condition than in any of the other treatments, and the failures recorded may be regarded as due only to the effect of Liver of Sulphur on the buds. If this assumption is justifiable then it may be concluded that treatment for 5 minutes in 1 per cent. Liver of Sulphur solution does injure buds unless the budwood is washed immediately after treatment.

TABLE V.

Box No. 5, Ammonium Polysulphide.

Treated, December 1st, 1930. Budded, December 8th, 1930. Opened and inspected, December 24th, 1930. Second inspection, January 16th, 1931.

Treatment No.	Condition of Budwood at time of Budding.	Successes 1st inspection per cent.	Successes 2nd inspection per cent.
C. U.	Fair ; sticks too green ; many buds sprouted ; difficult to find sufficient for 100 buddings. -	88	69
C. W.	Fair ; Do.	96	83
XVII. W.	Very good, except one stick with 6 ins. dieback. -	94	92
XVII. U.	Good ; 1 - 2 ins, die-back. -	92	86
XVIII. W.	Excellent. -	100	100
XVIII. U.	Excellent. -	98	92
XIX. W.	Good, except on one green stick with 8 ins. die-back ; sufficient buds obtained from other sticks. -	100	100
XIX. U	Poor ; one stick badly waxed died back 9 ins ; others 4 ins. -	70	58
XX. W.	Good, except one stick badly waxed which died back 9 ins. -	92	88
XX. U.	Fairly good ; 2 - 4 ins. die-back. -	88	80

There had been heavy rain early in the morning on which this box of material was budded, and the nursery was unusually wet until after the budding of the controls had been completed. This fact, coupled with the fact emphasized in the above table, viz. that the budwood was too young and that it was difficult to find 100 unsprouted sound buds, may well account for the comparatively few successes obtained from both the controls. It is interesting to note that the washed controls, in which the budwood was in precisely the same condition as in the unwashed controls, but which were budded after the nursery had dried considerably, gave a greater percentage success.

The other results are difficult to interpret, and in any case do not indicate any striking toxic action of ammonium polysulphide at the concentration employed. It is difficult to understand why the weakest treatments should give lower results than the treatments of medium intensity, unless the effect of the wet nursery was more prolonged than on other days. The low percentage success obtained in treatment XIX. U. is certainly anomalous, and may be correlated with the exceptionally poor condition of the budwood when unpacked; but since laboratory examination showed that the budwood was thin and full of pith, it was probably too immature to have given good results even under favourable circumstances.

The only figure which may be significant is the last one, obtained from the strongest treatment. The budwood was in quite good condition, and yet only 88 per cent. success was recorded.

The conclusion which must be reached is that ammonium polysulphide does no great harm to buds when they are exposed to strengths of 1 per cent. and 3 per cent. polysulphide sulphur for 2 minutes or 5 minutes, but that unless the budwood is washed after the strongest treatment (5 minutes in a 3 per cent. solution) there may be some mortality among the buds.

TABLE VI.

Box No. 6, Uspulun.

Treated, December 2nd, 1930. Budded, December 9th, 1930. Opened and inspected, December 25th, 1930. Second inspection, January 17th, 1931.

Treatment No.	Condition of Budwood at time of Budding.	Successes 1st inspection per cent.	Successes 2nd inspection per cent.
C. U.	Very good, except one stick. -	81	69
C. W.	Poor ; 6 - 8 ins. die-back on all sticks.	79	66
XXIII. W.	Good ; 1 - 2 ins. die-back. -	80	62
XXIII. U.	Good ; „ „ -	80	66
XXIV. W.	Fairly good ; two sticks with 2 - 3 ins. die-back. -	94	84
XXIV. U.	Good ; 1 - 2 ins. die-back. -	84	64
XXV. W.	Very good ; 1 in. die-back. -	94	76
XXV. U.	Excellent. -	98	84
XXVI. W.	Excellent ; one stick, too young, gave only 12 unsprouted buds ; 24 taken from each of the others. -	92	82
XXVI. U.	Excellent. -	84	76

This box of material was budded in an area very heavily attacked by *Fomes lignosus*, and in the beds where the treatments in the upper half of the table were budded, the growth of the stocks was extraordinarily poor and irregular. The early morning was wet and subsequent cloudiness prevented quick drying; all these factors conspired to rob the results in the first half of the table of any significance. Unfortunately the controls were exposed to the most unfavourable conditions and suffered heavily.

The last three treatments were budded under favourable circumstances and, as the condition of the budwood was the same in each one and excellent in all, it is fair to assume that the bud mortality was proportional to the lethal effects of the Uspulun. If these latter results are significant, they indicate that treatment for 5 minutes in 1 per cent. Uspulun without subsequent washing will cause considerable

mortality among the buds, while even if the budwood is washed after such treatment some deaths will still occur. However, treatment for 5 minutes in 0.5 per cent. Uspulun even without washing has no deleterious effect.

TABLE VII.

Box No. 7, Sulphur Dust.

Treated, December 3rd, 1930. Budded, December 10th, 1930. Opened and inspected, December 26th, 1930. Second inspection, January 18th, 1931.

Treatment No.	Condition of Budwood at time of Budding.	Successes 1st inspection per cent.	Successes 2nd inspection per cent.
C.	Good, except one stick with 6 ins. die-back. -	84	69
XXI.	One stick very good ; rest poor ; 4 - 8 ins. die-back. -	86	72
XXII.	One stick good, three excellent, two very poor with 6 - 8 ins. die-back. -	82	66

This is the box which unfortunately had to be left in the hands of the subordinate staff. The waxing was done very badly as is seen from the extreme variability of the condition of the bud sticks. However, each treatment and the control suffered alike, and the results indicate at least, that neither treatment had a markedly injurious effect on the budwood.

TABLE VIII.

Box No. 1, (repeated) Copper Sulphate.

Treated, December 5th, 1930. Budded, December 12th, 1930. Opened and inspected, December 28th, 1930. Second inspection, January 20th, 1931.

Treatment No.	Condition of Budwood at time of Budding.	Successes 1st inspection per cent.	Successes 2nd inspection per cent.
C. U.	Poor ; 6 - 9 ins. die-back. -	72	50
C. W.	Poor ; Do. -	72	41
I. W.	Fair ; 2 - 6 ins. die-back. -	62	50
I. U.	Very poor ; especially on young sticks. -	20	10
II. W.	Good on one stick, fair on the rest.	56	46
II. U.	Fair on two sticks, poor on one with 1 ft. die-back. -	26	18
III. W.	Fair on older sticks ; 4 ins. die-back, poor on younger ones; 6 - 12 ins. die back, only 49 buds available. -	46	37
III. U.	Fair on oldest stick, very poor on younger ones ; 6 - 12 ins. die-back, only 46 buds available. -	30	20
IV. W.	Very poor indeed ; 1 - 2 ft. die-back, only 46 buds available. -	30	15
IV. U.	Hopeless ; youngest stick dead to 2 ft. others to 1 - 2 ft; only 41 buds available. -	12	0

In order that the preparation of this box of material could be personally supervised, it had to be treated and packed after the budding of Box No. 3 on December 5th. The budwood had to be cut in the morning, and was placed with its ends in water until packing could be commenced. The budwood must have suffered to some extent from drying out, but since the controls were waxed and packed last of all they should have suffered most.

The results indicate that the control had suffered considerably, but in spite of this the treated budwood gave in all cases lower percentage successes. The results are very striking and illustrate the soundness

of the method used in this investigation, for with one exception (I.U.) the mortality of the buds rose rapidly and regularly with the severity of the treatment until after an immersion for 5 minutes in 5 per cent. copper sulphate, only 12 per cent. of the buds remained viable. Besides giving confidence in the methods employed, these results also indicate how washing with water after treatment affects the severity of the injury to the buds. In every case it is seen that washing with water before packing, i.e. removing the disinfectant entirely from contact with the buds at the end of the specified time, placed the treatment in a much lower class for severity.

With regard to disinfection with copper sulphate, it may be concluded that all the treatments tried were too severe, and treatment with a 5 per cent. copper sulphate solution is quite out the question. Even immersion for 2 minutes in 2 per cent. copper sulphate with subsequent washing is shown to be deleterious, and the experiment ought to be repeated using 1 per cent. for 2 minutes and 5 minutes, and perhaps 0.5 per cent for the same periods of time.

The budwood was so seriously injured by treatments IV.U., IV. W., III.U., III. W., and I.U. (the anomalous result), that in spite of the presence of the copper sulphate a general growth of surface mycelium was seen on the sticks when the damp fibre was removed, while the dead portions were covered with growths of moulds.

The abnormally low result obtained from I.U. is further explained by the fact that laboratory examination showed the budwood to be thin and full of pith, and the buds too immature for successful budding.

The Second Inspection.

After an interval of 23 days from the first inspection, the bud patches were examined for the second time. It was not expected that the results obtained from this second inspection would be as significant as those obtained from the first, and they were intended to be corroborative only.

In the short interval between budding and the first inspection all the buds were under the same conditions, except with regard to the vigour of the stocks (as influenced by soil, diseases, etc.), but between the time of budding and the final inspection the bud patches were exposed to these differences in vigour for 39 days, and for the latter 23 days of that period lacked the protection afforded by the budding tapes from the effects of unequal exposure to light, heat and precipitation. Furthermore, some of the stocks were required by the Botanical Division for budding purposes, and in the beds where these buddings were made many of the original bud-patches were partially or completely covered by budding tape for periods of one to two weeks prior to the second examination.

The results were obtained too late to be discussed collaterally with those from the first examination, since this paper was prepared before the second examination was completed, but as their purpose was confirmatory only they may be considered now briefly as a whole.

The successes obtained from the second inspection were more irregular than those obtained from the first, and taken alone cannot be regarded as significant, but when considered in conjunction with the results from the first examination they indicate, in general, an exaggeration of the differences between the effects of the various treatments as there expressed. Treatments which produced high percentage successes at the first examination showed a high percentage still at the second; while those which caused considerable mortality among the buds 16 days after treatment, caused a very severe drop in viability at the end of 39 days.

The results of the second inspection do not demand any change in the conclusions reached from a consideration of those obtained at the first inspection.

The accompanying table, Table IX, summarises all the numerical results obtained, and is intended for easy reference only. It must be considered in conjunction with the previous sections of this paper.

TABLE IX.

Fungicide.		Successes (1st inspection) per cent.						Successes (2nd inspection) per cent.					
		2 Minutes.		5 Minutes.		Controls.		2 Minutes.		5 Minutes.		Controls.	
		W	U	W	U	W	U	W	U	W	U	W	U
Solbar -	1 per cent	81	76	98	90	95	97	74	74	80	84	83	85
	2 ,, ,,	90	96	98	92			80	82	96	86		
Lime sulphur (B) -	1 ,, ,,	100	98	100	100	99	93	90	94	92	98	95	85
	5 ,, ,,	92	96	90	82			90	96	82	78		
Sulfinette -	2 ,, ,,	86	94	96	96	85	95	84	90	90	94	78	78
Liver of Sulphur -	1 ,, ,,	88	94	100	90			80	82	92	80		
Ammonium polysulphide -	1 ,, ,,	94	92	100	98	96	88	92	86	100	92	83	69
	3 ,, ,,	100	70	92	88			100	58	88	80		
Uspulun -	0.5 ,,	80	80	94	84	79	91	62	66	84	64	66	69
	1 ,, ,,	94	98	92	84			76	84	82	76		
Sulphur dust -	½ lb.			86		84				72		69	
	1 lb.			82						66			
Copper sulphate -	2 per cent	62	20	56	26	72	72	50	10	46	18	41	50
	5 ,, ,,	46	30	30	12			37	20	15	0		

Discussion.

Several points of practical importance arise from these results. In the first place the possibility is established of disinfecting budwood when being packed for export without causing any harm to the buds, as long as certain intensities of treaments are not exceeded. The fungicides employed are known to be toxic to fungi such as Phytophthora under laboratory conditions even at the lowest concentrations employed in this experiment, but whether they have any useful fungicidal action at the above mentioned limiting concentrations against fungi lying dormant under bud scales, or on the surface of the budsticks, is a matter for further investigation. The latter point could have been cleared up to some extent in the present instance if it had been possible to cut back the budded stocks, allow the buds to grow away normally, and to record the appearance of die-back fungi among the various treatments. This was not possible as the Botanical Division needed the stocks for further budding work, and when the buds had grown sufficiently to enable the second inspection to be made they were cut out.

It must be remembered that only one clone has been dealt with in the foregoing experiments and that no generalisation can be made to include all types of budwood. It is most probable that results of the same type would have been obtained no matter what clone had been used, but until experiments of a like nature have been performed on a range of clones these results must apply to clone AVROS 50.

Another important point that has been established is that the washing of budwood after disinfection merely has the effect of weakening the toxicity of the treatment towards dormant buds and that, as far as viability of buds is concerned, weaker and therefore cheaper solutions used without washing will produce the same results as are produced by stronger and more expensive solutions when the material is washed after treatment. If it is found in subsequent experiments that short exposures of dormant fungi to strong disinfectants are more effectively toxic than prolonged exposures to weak ones, then the process of washing budwood after treatment will have an important practical application. If, as is more likely, dormant fungi are found to be affected by disinfection in the same kind of way as dormant buds are affected, then washing with water after treatment will have no practical value.

The results also indicate to what extent damage can be done to budwood by faulty waxing, or the use of wax with a high melting point, for throughout the experiment there was a high correlation between the condition of the sticks—as judged by the amount of the die-back of the bark at the ends—and the percentage success of the buddings made from them. When budwood is being cut and exported commercially on a large scale the following recommendations may be made:—

1. A wax should be used with a melting point lower than that of Entwas, but high enough to prevent softening under air temperatures.
2. A special melting tank should be installed provided with an automatic temperature control. The prevention of loss to consignments of budwood through excessive heating during waxing will repay the cost of this extra equipment.

Conclusions.

The following are the greatest intensities at which the various fungicides under investigation may be used to disinfect budwood from clone AVROS 50 without any resultant injury to the buds.

Solbar. Immersion for 2 minutes in a 2 per cent solution, or for 5 minutes in a 2 per cent. solution if washed immediately with water.

Lime-sulphur (B). Immersion for 5 minutes in a 1 per cent. solution is safe but for 2 minutes in a 5 per cent. solution is too strong. Another experiment should be conducted using a 2 per cent. solution.

Sulfinette. Results indefinite, but soaking for 5 minutes in a 2 per cent. solution has no serious effect. Experiments should be carried out using a 3 per cent. solution.

Liver of Sulphur. Immersion for 2 minutes in a 1 per cent. solution, or for 5 minutes in a 1 per cent. solution if washed immediately afterwards in water.

Ammonium polysulphide. Immerson for 2 minutes in a 3 per cent. (polysulphide sulphur) solution, or for 5 minutes in a 3 per cent. solution if washed afterwards with water.

Uspulun Universal. Immersion for 2 minutes in a 1 per cent. solution.

Sulphur dust. Results indefinite, but apparently the inclusion of 1 lb. of sulphur dust in the fibre required to wrap 6 sticks had no serious effect on the buds. This series of treatments should be repeated using also $1\frac{1}{2}$ lbs. of sulphur to the same quantity of packing material.

Copper sulphate. The limiting concentration was exceeded even in the weakest treatment. The experiment should be repeated using 1 per cent. and 0.5 per cent. solutions instead of those employed above.

Acknowledgement.

The writer wishes to take this opportunity of expressing his indebtedness to Mr. C. E. T. Mann for invaluable assistance in all the problems encountered relative to budding, to Mr. F. Beeley for the inspection work carried out at the laboratory, and to Mr. A. R. Sanderson for suggesting the line of investigation and for continuous advice and suggestions during the course of the experiments.

TEST SPRAYING EXPERIMENTS ON YOUNG RUBBER PLANTS.

BY

F. Beeley.

The main object of the experiments described in this paper was to determine the concentrations at which various spray fluids might be used on one to two year old plants in the nursery without burning or damaging the leaves or stems.

A secondary object was to determine the efficiency of a single application of a fungicide in controlling leaf diseases (*Helminthosporium Heveae*—Bird's Eye Spot) and mite attack.

The following spray fluids commonly used in horticulture and fruit gardens were tried. A description of the method of preparation of the non-proprietary fluids is given.

Ammonium Polysulphide.

This is a commercial product containing approximately 21 per cent. of polysulphide sulphur and 19 per cent. of ammonia. It is a liquid which may be diluted to any required concentration by the addition of water. Concentrations up to 2 per cent. of ammonium polysulphide in water may safely be sprayed on young rubber trees.

Bordeaux Mixture.

This preparation is a valuable fungicide for combatting various plant diseases and consists of a mixture of copper sulphate and quicklime slaked in water.

The two standard mixtures in use are prepared according to the 4 : 4 : 50, and the 5 : 5 : 50 formulae.

Bordeaux Mixture 4 : 4 : 50.—Two separate solutions are first made as follows:—

No. 1. 4 lbs. of quicklime are slaked with a little water in a wooden or earthenware vessel and 24 gallons of water are then added.

No. 2. In a separate wooden or earthenware vessel 4 lbs of copper sulphate crystals are dissolved in 25 gallons of water.

Each solution is stirred separately, allowed to settle, and stored separately.

When required for use a known volume of solution No. 1, is slowly added to an equal volume of solution No. 2, in a wooden or

earthenware vessel stirring all the time. The mixed solutions must be well stirred immediately before using. Any excess of copper is ascertained by plunging a clean bright steel knife blade into the mixture. If copper is deposited on the steel more of solution No. 1. must be added until no deposition of copper occurs on the knife blade. If only a part of each preparation is to be used the lime mixture (No. 1.) can be preserved by adding 6 ozs. of sugar per 25 gallons of liquid and stirring until dissolved.

Bordeaux Mixture 5 : 5 : 50.—This is prepared in a similar way except that 5 lbs. of quicklime and 5 lbs. of copper sulphate are used in making up the solutions Nos. 1 and 2, resulting in a slightly stronger mixture.

Kerosene Emulsion.

Though possessing only weak fungicidal properties a kerosene emulsion is of great value as an insecticide for combatting Scale insects on the leaves and stems of nursery plants.

A 2 per cent. emulsion is prepared by dissolving one pound of common soap in one gallon of water by boiling. When the soap is completely dissolved and while the solution is still hot one pint of kerosene is added with continual stirring. The mixture must be stirred vigorously or churned with a syringe until a complete emulsion is obtained. Four gallons of hot water are then added with vigorous stirring.

The emulsion is ready for use when cooled but must be well stirred before application.

A 4 per cent. Kerosene Emulsion is prepared as above by using double the quantity of kerosene with the same quantity of soap as is used in the preparation of a 2 per cent. emulsion.

Kerosene Emulsion (2 per cent) and Lead Arsenate (0.5 per cent).

This mixture is considered an excellent insecticide and is made by adding 4 ozs. of Lead arsenate to each five gallons of the 2 per cent. Kerosene Emulsion prepared as above.

A stronger insecticidal and fungicidal spray fluid is made by adding 8 ozs. of lead arsenate per five gallons of kerosene emulsion. The latter strength has, however, been found to cause considerable burning of rubber leaves and is not recommended for general use in rubber nurseries.

Lime Sulphur.

A lime-sulphur preparation, besides being a good fungicide, is also one of the best known scale insecticides. Various proprietary

lime-sulphur mixtures are on the market, but the mixture may easily be prepared on the estate.

14 ozs. of quicklime are slaked and a little more water is added to make milk of lime. The mixture is strained and 35 ozs. of flowers of sulphur are stirred in and the mixture is diluted to one gallon by addition of water.

The mixture is boiled for one hour and the upper clear liquid is decanted from the sludge. The liquid thus prepared contains about 10 per cent. of polysulphide sulphur.

A 1 per cent. Polysulphide mixture is obtained by diluting to 10 gallons with water. This strength is satisfactory for disease control in rubber nurseries.

Owing to the fact that lime-sulphur mixtures tend to crystallise on standing for some time it is better not to prepare more than can be used on the same day. If, however, lime-sulphur mixtures, either home-made or proprietary, are to be stored for some time, the surface of the liquid should be covered with a layer ($\frac{1}{8}$ inch thick) of kerosene oil or, preferably, a mixture of four parts of kerosene oil to one part of lubricating oil. This will prevent evaporation and the formation of a crust on the surface of the fluid. The liquid must be kept in a closed vessel.

Lime Sulphur and Glycerine.

This mixture is prepared by adding 1 per cent. of crude glycerine to the above lime-sulphur mixture containing 1 per cent. of polysulphide sulphur in order to give a slightly more adhesive fluid. In the trials so far conducted the glycerine mixture has proved very little better than the ordinary lime-sulphur mixture.

Liver of Sulphur.

This is a commercial product in the form of a deliquescent solid packed in sealed tins. The commercial solid contains potassium polysulphide and on analysis shows an average content of 27 per cent. of polysulphide sulphur. A solution containing 1 lb. of solid liver of sulphur in 10 gallons of water, i.e. a 1 per cent. solution, is found to be most practicable, having at that strength a strong fungicidal action against leaf mildews.

Solbar.

This is a proprietary substance containing metallic polysulphides and carbon. It is stated to have both fungicidal and insecticidal properties when used in concentrations of 1—2 per cent. in water, carbon being left behind as a sludge in the mixing tank.

S 75.

This proprietary substance is a bluish white powder containing copper salts. It is a substitute for Bordeaux mixture and is more stable under ordinary atmospheric conditions. It may be used as a fungicide to combat leaf mildews by dissolving in water in concentrations of 1 to 4 per cent.

Sulphur.

Sulphur dust has proved effective in the control of leaf mildews and mites. Finely powdered quicklime may be added to the extent of 10 to 20 per cent. of the final mixture to act both as a drying agent and insecticide. The most efficient and economical mixture is prepared by using very dry and fine powders.

Sulfinette.

Sulfinette is a proprietary lime-sulphur mixture. It is a liquid which may be diluted to any strength by adding the required amount of water. The mixture if stored must be kept tightly sealed, otherwise sulphur and calcium sulphide crystallise out to form a thick crust while the efficiency of the fungicide becomes seriously impaired by decomposition and loss of the polysulphides which it contains.

EXPERIMENTAL INVESTIGATIONS.

Description of Plots.

The plots for the experiments consisted each of 200 nursery plants. Each plant was 1 year 9 months old and had been pruned to 4 feet some three months before the spraying was commenced. During these three months a luxuriant crown of foliage had developed to a height which rendered easy observation of the leaves.

Method of Application of Spray fluids.

The spray fluids were carried to the nursery blocks in buckets, and applied to the trees by means of mist sprayers of the hand type. One gallon of liquid mixture was applied to each plot.

On the sulphur dusted areas 5 lbs. of the sulphur and lime powder were applied to each plot by means of a foot duster.

Effect of a single spraying on the tissues of the rubber plants.

From Table 1, which gives a summary of the results it will be seen that, although in no case did the spray liquids adversely affect

the stems, several of the liquids burned the leaves, and in a few cases to such an extent as to cause the burned leaves to fall. It was observed that the chief seat of burning was on the lower sheltered leaves, the upper exposed leaves washed by the rains did not suffer so much damage.

Burning of Leaves.

The burning was of two types:—(1) rapid—visible in the form of light brown angular blotches within two to three days of the application of the spray fluid. If a quarter or more of the leaf surface is so burned the leaf invariably falls within a few days.

Fungicides causing this type of burning are Kerosene Emulsion plus Lead arsenate at a strength of 0.5 per cent. or over, Lime Sulphur in 5 per cent. solution and to a less extent Kerosene Emulsion of 4 per cent. strength, Lime Sulphur of 2 per cent. strength and Bordeaux mixture 5 : 5 : 50.

(2) Slow—visible in the form of pale green circular spots beneath a dried deposit of the spray fluid after 9—10 days from the date of application of spray. This effect is probably due to a slow poisoning of leaf tissues by the chemical deposit from the fungicide. Such leaves rarely fall but remain mottled in appearance.

Fungicides causing this type of burning are Liver of sulphur of 1 per cent. and 2 per cent. strength, Solbar of 2 per cent. strength, S. 75 of 2 per cent. strength, and a 5 per cent. solution of ammonium polysulphide.

Intensity of Deposit.

A rough indication of the power of adhesion to leaf surfaces and of the durability of the fungicide is given by the intensity of the deposit on the leaves after a period of 26 days. It is not, however, a measure of the fungicidal properties of the spray fluid. Too heavy a deposit may induce leaf fall.

Induced Leaf Fall.

This occurred in four of the plots sprayed respectively with kerosene emulsion (2 per cent.) plus lead arsenate (0.5 per cent.), kerosene emulsion (2 per cent.) plus lead arsenate (1.0 per cent.), lime sulphur mixture containing 5 per cent. of polysulphide sulphur and ammonium polsulphide of 5 per cent. strength. Spray fluids of this strength are therefore not to be recommended for use in rubber nurseries. Since a 5 per cent. solution in water of commercial ammonium polysulphide contains only 1 per cent. of polysulphide sulphur it is probable that the burning effect and leaf fall is due to the

ammonia content which is also 1 per cent., as lime sulphur mixtures containing up to 2 per cent. of polysulphide sulphur do not induce leaf fall.

Control of mite attack and disease.

The apparently close connection between mite attack and fungus diseases of leaves of nursery plants makes it difficult to differentiate between the efficiencies of a spray mixture: (a), as an insecticide, (b) as a fungicide. However, in nurseries it is often essential to have a dual purpose spray mixture.

Table 1. gives a summary of the results of the spraying experiment. The columns headed "Mites" and "Remarks" deal chiefly with the condition of the young flush of leaves developed since the spray mixtures were applied. In practically every case excellent control of both mites and disease was obtained on the leaves present previous to the application of the spray mixture.

It will be seen also from Table 1. that the three plots Nos. 23, 24 and 25 sprayed with the stronger concentrations of ammonium polysulphide solution showed excellent control of mites and disease on the young leaves. Nos. 13 and 14 sprayed with Bordeaux mixtures show complete control of mites but only partial control of disease on the young leaves.

Liver of Sulphur, Kerosene Emulsion and Sulphur-Lime mixtures also exhibit strong insecticidal properties while the fungicidal properties are not so good. S. 75 should prove efficient as both an insecticide and fungicide for application to nursery plants providing it can be supplied cheaply.

Kerosene Emulsion + 1.0 per cent lead arsenate proved efficient as a dual purpose spray fluid but its tendency to burn the leaves and its poisonous nature make it undesirable for general use.

Solbar at 2—3 per cent. strength should prove a good spray mixture for Hevea nurseries though it has a slight tendency to cause burning of the leaves.

Sulfinette at concentrations between 3 and 5 per cent. is a good dual purpose mixture, ranking closely to the home-made lime-sulphur mixtures.

It should here be pointed out that Goodwin and Martin (Ann: Applied: Biol: 1930. Vol. xvii, No. 1, pp. 127—136), after a prolonged investigation of the fungicidal properties of solutions containing sulphur in polysulphide form on the hop powdery mildews conclude that, in all cases, the fungicidal efficiency is determined solely by the content of polysulphide sulphur of the spray fluid. Hence the purchase and use of proprietary spray fluids of this type, such as ammonium polysulphide, Sulfinette, Solbar, Liver of Sulphur and Lime Sulphur, should be based upon the percentage content of polysulphide sulphur and not upon the total sulphur content.

Comparative Prices of Spray mixtures per 10 gallons of diluted fluid.

Ammonium Polysulphide	1 per cent. solution ...	$0.30
,, ,,	1 per cent. polysulphide sulphur	1.43
Sulfinette	1 per cent. solution ...	0.16
,, 4 per cent	5 per cent. solution ...	0.80
,, solution	1 per cent. Polysulphide sulphur	0.64
Lime Sulphur (Monro)	1 per cent. Polysulphide sulphur	0.40
Lime Sulphur (B)	1 per cent. Polysulphide sulphur	0.33
Liver of Sulphur	1 per cent. solution ...	1.00
Kerosene Emulsion	2 per cent. ...	0.57
,, ,,	4 per cent. ...	077
Solbar	1 per cent. solution ...	0.25
Bordeaux	4 : 4 : 50 ...	0.33
,,	5 : 5 : 50 ...	0.36
Sulphur dust + 10 per cent. of Lime	per 10 lbs. ...	0.61
Sulphur dust + 20 per cent. of Lime	per 10 lbs. ...	0.50

The above prices are based on the prices in Malaya of the products given below.

Bulk Prices in Malaya.

Ammonium Polysulphide...	$3.00 per gallon.
Sulfinette ...	8.00 per 5 gallon drum.
Copper Sulphate ...	17.50 per cwt.
Liver of Sulphur ...	1.00 per lb.
Lime Sulphur (Monro) ...	1.00 per gallon.
Lime ...	16.00 per ton.
Glycerine ...	7.50 per gallon.
Soap ...	0.15 per lb.
Kerosene ...	0.63 per gallon.
Sulphur ...	130.00 per ton (6 cents per lb.)
Solbar ...	2.70 per 11 lbs. tin.
S. 75 ...	Not quoted ($7.00 per 56 lbs.?)
Arsenate of Lead ...	0.75 per lb.

Conclusions.

From the above results it appears that although a single application of a spray mixture is sufficient to decide within two or three days whether or not the concentration is so high as to cause damage to the leaves, it is insufficient to give adequate control of the diseases affecting the leaves.

It is suggested, therefore, that, in order to effect such control, two or even three applications at intervals of 14 days be given. By this means protection is given to such leaves as may develop immediately following the first spraying.

Grateful acknowledgement is made to Mr. A. R. Sanderson for advice during the course of the investigation and to Dr. A. S. Corbet for his analyses of various spray fluids.

Summary.

1. A list of available spray fluids together with methods of preparation of non-proprietary articles is given.
2. The effect of the spray fluids at different concentrations is given in tabulated form while the efficiency of a single application of spray fluids is discussed from the point of view of disease control.
3. Comparative prices of the spray fluids are included for guidance.

TABLE I.

EXPERIMENTAL SPRAYING TO DETERMINE EFFECT OF SOLUTIONS AT DIFFERENT STRENGTHS ON LEAVES.

Sprayed one gallon of mixture to 200, 2 year old plants. Examined (1) after 5 days, (2) after 13 days, (3) after 26 days from time of spraying.

Dusted 5 lbs. of dust mixture to 200, 2 year old plants. ×, +, −, represent much, little, and no burning respectively.

Plot No.	Spraying Mixture.	Concentration of Spray Mixture per cent.	Burning.			Where burnt or damaged.	Deposit of mixture on leaf surface.	Leaf Fall.	Mites.	Remarks. Condition of leaves which developed after spraying.
			1	2	3					
1	Sulfinette -	1	−	−	−		Negligible		Many	Young leaves diseased.
2	Sulfinette -	2	−		−		,,		Few	Young leaves diseased.
3	Sulfinette -	5	−		−		Slight			Young leaves diseased.
4	Lime Sulphur "B" Polysulphide -	1	−		−		,,		Few	Young leaves diseased.
5	Liver of Sulphur -	1	−	−	−	Fairly evenly in spots -	Very slight			Young leaves diseased.
6	Liver of Sulphur -	2	+	+	+	In spots over surface of leaf -	,,			Fairly healthy leaves.
7	Kerosene Emulsion -	2	−	−	−	Pale spots -	None			Young leaves diseased.
8	Kerosene Emulsion -	4	+	+	+	Occasional leaves in blotches -	None			Fairly healthy leaves.

TABLE I.—(Contd.)

Plot No.	Spraying Mixture.	Concentration of Spray Mixture per cent.	Burning. 1	2	3	Where burnt or damaged.	Deposit of mixture on leaf surface.	Leaf Fall.	Mites.	Remarks. Condition of leaves which developed after spraying.
9	Kerosene Emulsion - Lead arsenate -	2 / 0.5	+	×	+	Blotches on large immature leaves -	Slight	Slight	Few	Young leaves diseased.
10	Kerosene Emulsion - Lead arsenate -	2 / 1	×	×	×	In blotches, leaf subsequently falls -	Slight	Slight		Young leaves healthy. Stems not affected.
11	Solbar -	1	–	–	–		Slight		Few	Much disease in young leaves.
12	,,	2	–	+	+	In spots on tender leaves -	Slight			Fairly healthy leaves.
13	Bordeaux Mixture 4-4-50 -		–	–	-	Slight burning in spots on few leaves -	Slight			Fairly healthy leaves.
14	Bordeaux Mixture 5-5-50 -		+	+	+	Slight in blotches on tender leaves -	Slight			Fairly healthy leaves.
15	Lime Sulphur B -	2	+	+	+	Burned in blotches at edge -	Slight			Slight disease in young leaves.

TABLE I.—(Contd.)

Plot No.	Spraying Mixture.	Concentration of Spray Mixture per cent.	Burning. 1	2	3	Where burnt or damaged.	Deposit of mixture on leaf surface.	Leaf Fall.	Mites.	Remarks. Condition of leaves which developed after spraying.
16	Lime Sulphur B -	5	+	+	+	Over all leaf surface in spots -	Heavy	Slight		Remaining foliage good and healthy.
17	Sulphur Dust + 10 per cent Lime -		–	–	–		None			Slight disease, some appear eaten by insects.
18	Sulphur Dust + 20 per cent Lime -		–	–	–		None			Slight disease in young leaves.
19	Lime Sulphur B (1 per cent) + 1 per cent Glycerine -		–	–	–		Slight		Few	Slight disease in young leaves.
20	S. 75 -	1	–	–	–		None		Few	Young leaves diseased.
21	,, -	2	–	–	+	Slight in few lower leaves -	None			Appear eaten by insects, slight disease.
22	,, -	5	–	+	+	Slight on lower leaves.	None leaf mottled			Young leaves healthy and vigorous.

TABLE I.—(Contd.)

Plot No.	Spraying Mixture.	Concentration of Spray Mixture per cent.	Burning. 1	2	3	Where burnt or damaged.	Deposit of mixture on leaf surface	Leaf Fall.	Mites.	Remarks. Condition of leaves which developed after spraying.
23	Ammonium polysulphide -	1	–	–	+	Slight in spots -				Young leaves healthy and vigorous.
24	Ammonium polysulphide -	2	–	–	+	Slight in spots -	Slight			Young leaves healthy and vigorous.
25	Ammonium polysulphide -	5	–	+	+	Burnt in blotches which drop out -	Medium	Slight		Leaves appear eaten by insects, young leaves mainly healthy.

THE OUTPUT OF ESTATE SHEETING BATTERIES.

BY

E. Rhodes & R. O. Bishop.

Present estate factory practice demands in an increasing measure the utilisation of existing plant for the production of larger quantities of rubber conforming to a higher standard of quality. The following article considers this problem in the light of information obtained from the results of a questionnaire on factory sheeting batteries.

Introduction.

In order to gather data concerning the average practice adopted throughout the country, a large number of estates were circulated with the following questionnaire:—

1. Crop treated, in lbs. of dry rubber per hour.
2. Number of machines. { Smooth Rolls. / Markers.
3. H.P. of Engine.
4. Approximate R.P.M. of rolls.
5. Width of Rolls. { Smooth Rolls. / Marking Roll.
6. Diameter of Rolls. { Smooth Rolls. / Marking Roll.
7. Number of times sheet passes through each machine.
8. Original width of coagulum from tank and whether hand rolled.
9. Final Width of { Wet Sheet, / Dry Sheet.
10. Thickness of Sheet or weight of Dry Rubber per foot length. (Note.—Several feet to be measured to give average).
11. Is coagulum rolled on day of coagulation or next day.
12. Concentration of standard latex. (lbs. per gallon).
13. Distance between division plates in tank.
14. Any remarks on relation between width of sheet and packing cases.

The replies received from 200 estates were tabulated and analysed to ascertain the relationship existing between:—

(a) Width of Dry Sheet and Output per battery hour.

(b) Width of Coagulum and width of Wet Sheet.
This embraces variations due to "same day" and "following day" machining.

(c) Width of Wet Sheet and corresponding width of Dry Sheet.

(d) Thickness of Sheet, as defined by weight per square foot, and Concentration of the Latex before coagulation.

(e) Speed of Machine rolls in feet per minute and Output per battery Hour in lbs. of dry rubber.

When the information was summarised with a view to ascertaining these relationships it became evident that further variables were involved and required consideration; thus with (a) it is valueless to consider width without also taking into account thickness and, for a true representation of the facts, it is necessary to make the comparison in terms of sheet of a standard thickness. It was decided that a suitable standard of thickness would be represented by a sheet weighing ½ lb. per square foot. The actual figures for output appearing in the questionnaire replies were therefore adjusted so that the figures used for comparison represented in each case what the output would be if the battery were producing sheet weighing precisely ½ lb. per square foot.

In the same manner it was found essential to introduce the factor of standard width into the considerations involved; if the standard thickness is combined with standard width, a true comparison of outputs is obtained. It was decided to adopt 12 inches as the standard width.

The figures adjusted on this basis then show the relative efficiencies of batteries of similar type.

For example, Estate No. 14 is reported to be manufacturing 547 lbs. per battery hour. The weight of the sheet is 10.1 ozs. per square foot, the sheet itself being 15½ ins. wide. If the weight per square foot were 8 ozs. the output per battery hour would be 433 lbs. for a sheet 15½ in. wide, and if the sheet were 12 ins. wide instead of 15½ ins. the output would be still further reduced to 335 lbs. per hour.

In comparison, Estate No. 17, having the same type of battery, is reported to be manufacturing 324 lbs. per hour as against 547 lbs. reported by Estate No. 14, but we find that Estate No. 17 is making sheet 10 in. wide, weighing 7.8 ozs. per square foot. By adjusting for these values on the above lines it is found that the output of standard thickness sheet would be 332 lbs. and the output of sheet of standard thickness and standard width would be 399 lbs. per hour. Therefore Estate No. 17 is actually handling rubber more efficiently than Estate No. 14 although the bare questionnaire reply indicates the reverse. Table 1 shows some of the figures obtained from the questionnaire set out in the manner indicated in the above example and the end column of the Table summarises the results in a figure representative of battery efficiency.

TABLE I.

Estate No.	Actual Output Dry Rubber lbs. per hour.	Number of Machines		H.P. of Engine	Roll Speed Ft. per Min. Machine				Width of Rolls		D.R.C. of latex lbs. per gal.	Width of Coagulum	Width of Sheet		Wt. per foot length	Wt. per sq. ft.	Output of Sheet of Standard Thickness.	Output of Sheet of Standard Thickness and Standard Width
		Smooth	Marker		1	2	3	M.	Smooth	Marker			Wet / Dry					
												Inches.	Inches.		Lbs.	Ozs.	Lbs.	Lbs.
1	454	3	1	5	55	70	70	45	20	20	1.50	9.0	16	14	0.53	7.2	504	432
2	296	3	1	5	50	50	50	50	18	18	1.00	8.0	14	13	0.50	7.4	320	295
3	325	3	1	4	55	75	75	55	20	20	1.25	7 0	10	9	0.50	9.6	271	343
4	570	3	1	3½	60	60	60	60	20	20	1.50	8.0	14	13	1.00	15.5	294	274
5	400	3	1	5	55	55	55	60	18	18	1.25	10.0	12	11½	0.60	9.4	341	355
6	514	3	1	5	55	55	55	60	18	18	1.25	10.0	12	11	0.44	7.6	541	591
7	311	3	1	5	45	45	45	40	18	18	1.50	10.0	13½	13	0.44	6.5	383	353
8	311	3	1	12	35	35	35	45	18	18	1.50	6.6	14½	14	0.60	8.2	303	260
9	475	3	1	5	40	40	40	40	20	20	1.25	6.5	11½	10	0.40	7.6	495	594
10	707	3	1	4½	70	70	70	70	20	20	1.25	9.0	13	12	0.54	8.6	655	655
11	310	3	1	5	45	45	45	25	18	18	1.50	11.0	14	13	0.75	12.6	207	187
14	547	3	1	3	55	55	55	50	20	20	1.5	10.3	16	15	0.79	10.1	433	335
17	324	3	1	3	40	40	40	40	15	15	1.25	8.0	10½	10	0.40	7.8	332	399
1	201	2	1	5	55	55		55	18	18	1.50	6.75	12	11½	0.55	9.6	168	175
2	314	2	1	6/7	40	40		45	18	18	1.50	10.0	14	12½	0.55	8.8	285	274
3 A	520	2	1	5	55	55		55	18	18	1.25	7.5	11	10	0.53	10.2	408	480
3 B	580	2	1	5	60	60		60	18	18	1.25	7.5	11	10	0.53	10.2	459	551
3 C	600	2	1	5	65	65		65	18	18	1.25	7.5	11	10	0.53	10.2	470	565

From the full list of figures of which Table 1 forms a part, some statistical analyses were made.

The values for coefficients of correlation were determined according to the conventional methods which have been applied and described elsewhere in this Journal and results were obtained for the following relationships:—

CORRELATION BETWEEN:

(a) *Roll speeds and output of standard sheet for batteries of similar type.*

For batteries consisting of three smooth machines and one marker, the coefficient of correlation between output of standard sheet and the speed of the fastest roll was found to be $+ 0.140 \pm 0.075$.

Similarly the coefficient of correlation between output of standard sheet and the speed of the slowest roll was $+ 0.128 \pm 0.075$.

For batteries having two smooth rolls and one marker the coefficient of correlation between output of standard sheet and the speed of the fastest smooth roll was $+ 0.170 \pm 0.097$.

From these figures it is evident that the correlation is in each case insignificant.

If it is assumed that all rolls are correctly adjusted and efficiently fed, then it follows from the above that the figures supplied on the questionnaire sheets were in most cases inaccurate. On the other hand, if it is assumed that the questionnaire replies are accurate, and we see no reason to doubt this, then the inference must be made *that rolls are not in general being correctly adjusted and/or efficiently fed.*

(b) *Width of Dry Sheet and Output of Battery.*

A study of the figures for the above relationship gave no conclusive information even when subjected to a close statistical analysis.

SUMMARY OF STANDARD OUTPUTS FOR BATTERIES OF SIMILAR TYPE.

If the figures recorded in Table 1 above are classified according to the type of battery and the gearing of the machines, useful criteria are obtained for the output values of standard sheet. These values are recorded below in Tables, II, III, IV and V.

Table II records some values for output of batteries having three smooth rolls and a marker running at different speeds.

Table III gives similar values for batteries in which all the rolls are running at the same speed.

Table IV gives values for batteries having two smooth rolls and a marker all of which are running at the same rate.

Table V records output of batteries employing instead of light sheeting rolls a marker combined with heavy smooth rolls from a crepeing battery geared in the usual manner.

In order to conserve space it has been considered sufficient to tabulate only those estates having standard outputs *above average for each particular group.* The average for each battery type is recorded at the head of each table.

TABLE II.

Light Battery Type.—3 Smooth Rolls and 1 Marker, running at different speeds.

Average Standard Output.—345 lbs. per hour.

Est. No.	Standard Output.	Roll Speeds. Feet per minute.		
		Marker.	1st Smooth.	2nd & 3rd Smooth.
25	432	45-50	55-60	70-75
89	405	40-45	40-45	50-55
119	493	45-50	45-50	65-70
122	500	45-50	55-60	55-60
123	392	60-65	65-70	65-70
131	401	50-55	65-70	90-95
171	415	45-50	55-60	55-60
175	412	45-50	35-40	55-60
192	392	40-45	50-55	65-70

TABLE III.

Light Battery Type.—3 Smooth Rolls and 1 Marker, running at the same speed.

Average Standard Output.—345 lbs. per hour.

Est. No.	Standard Output.	Roll Speeds. Feet per minute
12	384	30 - 35
17	399	35 - 40
20	393	55 - 60
32	410	80 - 85
24	345	55 - 60
66	444	45 - 50
83	355	55 - 60
84	591	55 - 60
88A	474	45 - 50
90	427	35 - 40
93	360	40 - 45
96	366	35 - 40
112	375	40 - 45
118	571	35 - 40
120	463	35 - 40
128	487	35 - 40
133	397	50 - 55
134	439	65 - 70
138	420	55 - 60
141	351	45 - 50
163	427	50 - 55

TABLE IV.

Light Battery Type.—2 Smooth Rolls and 1 Marker.

Average Standard Output.—301 lbs. per hour.

Est. No.	Standard Output.	Roll Speeds. Feet per minute.
5	323	35-40
40	345	70-75
29	431	70-75
51	398	35-40
56	545	65-70
78	348	40-45
79	419	40-45
102	489	55-60
135	350	55-60
128	487	35-40
74	320	55-60
165	305	30-35
168	329	50-55
173	418	40-45
193	370	45-50
185	336	40-45
195	506	50-55
200	333	40-45

TABLE V.

Heavy Battery Type.—Heavy Smooth Rolls and 1 Marker, 18 ins. × 12 ins.

Average Standard Output.—353 lbs. per hour.

Output above 354 lbs.		Speed of Marker.	Speed of First Rolls.	Speed of Other Rolls.
Est. No.	Standard Output.			
3	467	50-55	40-45	50-55
23	512	35-40	75-80	75-80
55	565	45-50	90-95	100-105
129	573	30-35	60-65	60-65

From these results, the following conclusions may be drawn:—

(a) Batteries having three smooth rolls and a marker show better standard outputs than those having only two smooth rolls and a marker.

(b) Roll speeds as high as 68—70 feet per minute can be used successfully on first machines, (vide Table V) and it is advantageous to have the machines geared to run at unequal speeds.

In other respects the results were conflicting and it was decided to obtain more data before attempting to draw further conclusions. It was felt that the inferences drawn from the above statistical analyses should be supplemented by experimental work designed to answer the following:—

(a) To what extent is the output of a battery dependent on the efficiency of the individual machines?

(b) To what extent can the output of a battery be improved by the correct harmonisation of the units in the battery?

(c) What is the maximum output which a factory can expect to maintain with the present type of plant?

With the above objects in view work has been carried out on several estates under normal conditions of factory procedure and test runs have been in hand for some time on the plant available at the experimental factory attached to the Chemical Division of the Institute.

It is considered that the results so far obtained are of sufficient interest to warrant publication but it must be emphasised that there still remain many problems unsolved relating to the efficient manufacture of plantation sheet.

As an illustration of the manner in which existing figures require scrutinising it is relevant to quote from observations on some estates which forwarded replies to our questionnaire.

Observations taken on Estate A.

Battery. Two smooth rolls and a marker.
Output **reported,** 700 lbs. per hour.
Output **observed,** 641 lbs. per hour.

Roll Speeds.

		1st Machine.	2nd Machine.	Marker.
Reported,	R.P.M.	26	26	30
Observed,	R.P.M.	29	29	29

Rolls, Diameter 7 inches. Peripheral speed of rolls 53.1 ft. per minute.

In a check run it was found that 348 sheets were machined in 88 minutes.

Time observed for machining separate sheets (mean figures)

Machine.	Time (Secs.)
1	12
2	12.7
3	8.1

Size of Sheet.

Wet Sheet = 17.75 in. × 53.4 in.
Dry Sheet = 14.5 in. × 49 in.

Weight of Dry Sheet.

40 sheets weighed 107.75 lbs. = 2.7 lbs. per sheet.

Weight of Dry Sheet per Square foot.

$$= \frac{2.7 \times 16 \times 144}{14.5 \times 49} = 8.75 \text{ ozs.}$$

Output per battery hour observed.

$$= \frac{348 \times 60 \times 2.7 \text{ lbs.}}{88} = 641 \text{ lbs. per hour.}$$

Output of 12 inch wide sheets would be $\frac{641 \times 12}{14.5} = 531$ lbs. per hour.

Output of 12 inch wide sheet weighing ½ lb. per sq. ft., i.e. Standard Output would be 485 lbs. per hour.

Rate at which rubber passes between the rolls.

348 sheets $= \frac{348 \times 53.4}{12}$ feet of rubber.

Now 1 sheet is handled in 12.6 seconds by the 2nd roll

∴ 348 sheets take $\frac{348 \times 12.6}{60}$ machining minutes = 73 min.

∴ Rolls handle rubber at the rate of $\frac{348 \times 53.4 \text{ ft.}}{12 \times 73}$

= 21.2 ft. per minute

Further the time occupied in handling = 15 minutes.

∴ One sheet occupies 2.6 seconds in handling.

From the observations made on the estate the peripheral speed of the rolls was found to be 53 feet per minute, and yet the sheet of rubber only leaves the smooth rolls at the rate of approximately 21 feet per minute and leaves the marking roll at the rate of 33 ft. per minute.

The fact that the ribbing on the marking rolls does not account for a greater efficiency in the output of the rolls appears to indicate that the differences between 53 (roll speed) and 21 (sheet speed) ft. per minute on the smooth rolls is not altogether accounted for by pure "slip". It may be described as "slip" for want of a better term, but we are of the opinion that it is a characteristic of the deformation of the rubber due to the nip of the rolls and in this connection some

further data which we have collected shows that the figure for slip, high though it may appear from the above, tends to increase still more when the coagulum which is being machined is tough and resilient and possesses elasticity preventing deformation. For this reason it appears desirable to machine very soft coagulum which is plastic and readily deformed and does not spring back like elastic the moment it is released from the nip of the rolls.

In order to investigate this further a piece of apparatus has been designed for measuring the plasticity or deformability of coagulum and it is hoped shortly to be in a position to publish some data connecting the "softness" of coagulum with efficiency of output.

The inference that plasticity of coagulum influences the machining of the crop was borne out by the results obtained in the Institute's Experimental Factory. Here the work has been carried out on 24 inch wide roll sheeting machines handling coagulum from tanks 16 inches deep.

The individual results obtained at the Institute led to the following conclusions:—

(a) A satisfactory sheet could be made from latex coagulated in a deep tank.

(b) Progress towards increased outputs and higher efficiency of sheeting plant is intimately connected with factors influencing the state of the coagulum such as density, plasticity and hardness.

(c) The efficiency with which the drying of the finished sheet can be effected is dependent on the handling and machining of the coagulum and is a consideration which must be given particular attention when any attempts are being made to increase the output of a battery.

(d) The depth and thickness of the coagulum made must be regulated by the accommodation of the smokehouse as well as the width of the machines.

Bearing in mind the above facts it has been possible to produce eminently satisfactory sheet at rates which would have been considered very improbable a year ago and for the purpose of illustrating these the following figures may be quoted:—

Observations taken on Estate B.

Plant Dimensions.

Coagulating tanks	...	18 inches deep, aluminium lined.
Partitions,	...	16 inches deep, aluminium.
Machines	...	3 smooth rolls and 1 marker.
Rolls	...	24 inches wide, 6 inches diameter.

Latex 1½ lbs. per gallon machined on the day after coagulation.

Width of the coagulum	(average of 7 sheets)	10.5 ins.
	(after hand pressing)	11.0 ins.

Length of coagulum from:—		*Time taken to pass through:—*	
1st machine	45.8 ins.	1st machine	13 seconds.
2nd ,,	48.0 ,,	2nd ,,	11.4 ,,
3rd ,,	57.2 ,,	3rd ,,	12.9 ,,
Marker	55.5 ,,	Marker	10.7 ,,

The sheet was even in appearance, but was possibly a trifle thicker than normal and was described by the Manager as being on the thick side for a satisfactory smoking in 7 days.

Dimensions of Dry Sheet.

Average of 24 random sheets = 16.8 ins. at ends and 15.8 ins. at middle.

Latex at 2 lbs. to the gallon coagulated and machined the same day.

Width of the coagulum (average of 7 sheets) ... 13.5 ins.
Length of coagulum ... 39.0 ins.

Time taken for sheet to pass through:—

1st machine ... 15.2 seconds
2nd ,, ... 12.1 ,,
3rd ,, ... 13.2 ,,
Marker ... 15.0 ,,
Width of wet sheet from Marker = 21 ins.
Length of wet sheet from Marker = 67 ins.

The sheet was somewhat thick and the average appeared to be over $\frac{1}{8}$ inch.

The handling of the coagulum presented unusual difficulties on account of the softness of the material and the size of the pieces to be put through the first machine. The operators were not used to this and it was only after fixing temporary chutes on which the coagulum could be passed into the first machine that it was found practicable to handle the pieces of coagulum without an abnormal amount of tearing. Observation showed, however, that if suitable chutes could be constructed permanently for the introduction of the rubber into the first and second machines the handling of these big pieces of coagulum would present little or no difficulty.

Dimensions of Dry Sheet.

Average of 24 random sheets 19.7 inches at ends and 18.5 inches in the middle.

The rubber was difficult to dry and in order to obtain a satisfactory cured sheet the ends had to be clipped extensively.

As a result of this it became evident that it would be necessary to employ a greater depth of latex for the purpose of obtaining an 18 inch finished dry sheet from latex diluted to below 2 lbs. to the

gallon and it appeared that the results obtained with that from latex at 2 lbs. to the gallon, coagulated and machined on the same day, were vitiated by difficulties in the smoking of the finished sheet.

Further trials were, therefore, carried out with latex diluted to $1\frac{3}{4}$ lbs. per gallon.

Observations taken on Estate C.

Plant Dimensions.

Coagulating tanks	...	18 inches deep, aluminium lined.
Partitions	...	16 inches deep, aluminium.
Machines	...	3 smooth rolls and 1 marker.
Rolls	...	24 inches wide, 6 inches diameter.

Latex at $1\frac{3}{4}$ lbs. D.R.C. machined on the day after coagulation.

Coagulum was passed directly into the 1st machine and not hand rolled.

Width of coagulum	=	13.0 inches
Length of coagulum	=	39.0 ,,

Time taken to pass through machines:—

1st machine	...	13 seconds.
2nd ,,	...	12 ,,
3rd ,,	...	11.5 ,,
Marker	...	15 ,,

Total time taken to machine 76 pieces of coagulum = 25 min.

Width of wet sheet from marker	=	19.8 inches.
Width of dry sheet	=	17.6 ,,
Weight of dry sheet	=	5.2 lbs.

The sheet took 11 days to smoke and needed some clipping to eliminate thick edges.

From these observations the following deductions were made:—

(a) Latex coagulated at $1\frac{3}{4}$ lbs. per gallon cannot be relied on to produce a dry sheet 18 ins. wide from 16 inches depth of latex.

(b) There is a danger of producing a sheet difficult to dry on account of thick edges.

(c) The 24 inch wide roll machines can roll 1,000 lbs. of dry rubber per hour and this output can be handled by one man per machine.

(d) The battery is capable of a much greater output if roll speeds of the units are better harmonised.

As a result of the above, further trials were made on the same plant with latex at 1¾ lbs. D.R.C. coagulated and machined the same day.

Capacity of tank 226 gallons. Coagulant added to latex at 1.30 p.m. Depth of latex between partitions 16 inches. Coagulum lifted at 3.30 p.m. Depth of coagulum between partitions varied between 12 and 14.5 inches.

The pieces of coagulum were very soft and represented the extreme degree of softness at which it would be possible to lift coagulum from the tanks into the first machine. It was found, however, that if the material could be supported as it was passed into the first machine it could be machined successfully and without tearing.

The rate at which the sheets passed through the machines was found to be approximately the same as that recorded above, and the output worked out at approximately 1,000 lbs. dry rubber per hour. The width of the wet sheet varied considerably—those sheets from the first 20 pieces of coagulum had widths between 19.5 ins. and 22 ins. and those from the last 20 pieces of coagulum varied in width between 22 ins. and 24 ins. These differences did not correspond to variations in the depth of the original pieces of coagulum.

The wet sheets gave a satisfactory marking and machined to a uniform thickness. The edges were soft and even.

It was found that the sheets smoked in 13 days over all, there was no delay in drying the ends and the colour and appearance of the finished rubber was satisfactory.

Weight of dry sheet 5.2 lbs. Width of dry sheet varied between 16.5 ins. and 19 ins.

From these figures and the observations made at the time of the trials it was evident that an attempt should be made to arrange for some method of improved handling of the coagulum from the tank to the first machine. If this could be done it would be possible to handle coagulum 2—3 hours after adding the coagulant and then 16 ins. depth of latex would produce a finished sheet of 18 inches width.

The necessary steps were taken to arrange for further trials in this direction and, pending these, some alterations were made to the gear ratio of the machines.

The results of these to date can be judged from the following figures taken during actual working conditions on Estate C.

Coagulum from latex containing 1¾ lbs. dry rubber per gallon to which the coagulant had been added the previous day.

Dimensions of coagulum	{	40 ins. long.
,, ,,	{	14 ins. to 11½ ins. wide.

Individual speeds and Outputs of separate machines.

	R.P.M.	Peripheral speed. Feet per min.	Time of Sheet through machine.	Dimensions of Sheet leaving machine Length.	Width.
1st Machine	27	40	13 secs.	45½ ins.	18 -16 ins.
2nd ,,	40	60	12.6 ,,	53½ ,,	20½-18½ ,,
3rd ,,	40	60	13.0 ,,	59 ,,	22¼-20 ,,
Marker	40	60	12.5 ,,	66 ,,	23 -21 ,,

Average width of dry sheet 17.4 ins.

Average weight of dry sheet 5.28 lbs.

Total time taken to machine 76 sheets = 18 minutes.

Therefore output of battery = 1337 lbs. dry rubber per hour.

It is of interest to note that if the output of Estate C is reduced to terms of standard output for comparison with the figures recorded previously (Table I.) the following values are obtained.

Average standard output of batteries having 3 smooth machines and one marker = 345 lbs. per hour.

Standard output of Estate C having 3 smooth machines and one marker = 645 lbs. per hour.

Conclusions.

The above results lead to the following conclusions:—

(1) The sheeting batteries on the majority of estates are not working efficiently. The harmonisation of the units can be improved and the handling of the coagulum is far from ideal.

(2) 18 ins. deep tanks and 24 ins. wide machines can be used to produce 18 inches wide standard quality sheet at rates up to 1400 lbs. of dry sheet per hour.

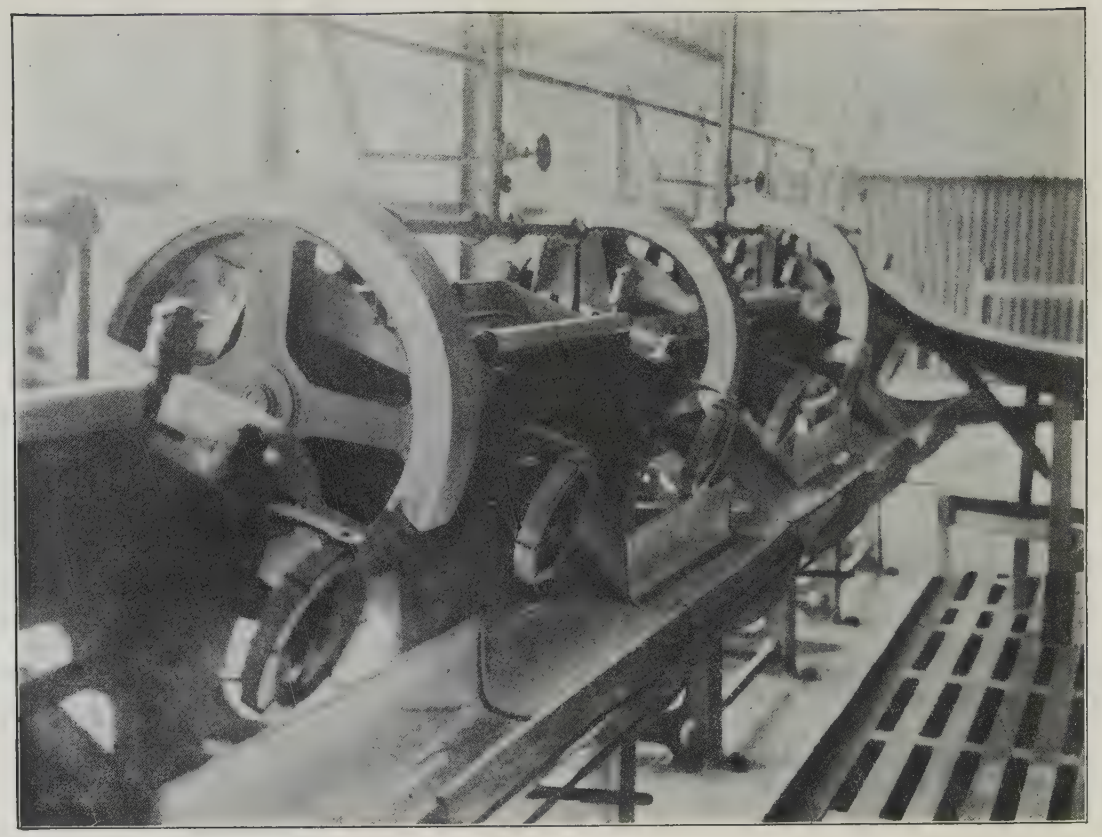
Acknowledgements.

Our thanks are due to the managers of the estates who replied to the questionnaire.

Particular thanks are due to Major C. H. A. Huxtable, D.S.O., Manager, Kalumpang Estate, Lt. Commander A. P. Mackilligin, M.B.E., Manager, Changkat Asa Estate, C. H. Hooper, Esq., Engineer, F.M.S. Rubber Company and R. C. Williams Esq., Sungei Sungkai Estate, for facilities accorded to us and collaboration in collecting data in their estate factories.

Special thanks are due to Lt. Commander A.P. Mackillingin for permission to publish the illustrations showing the sheeting machines and aluminium chutes installed in his factory.

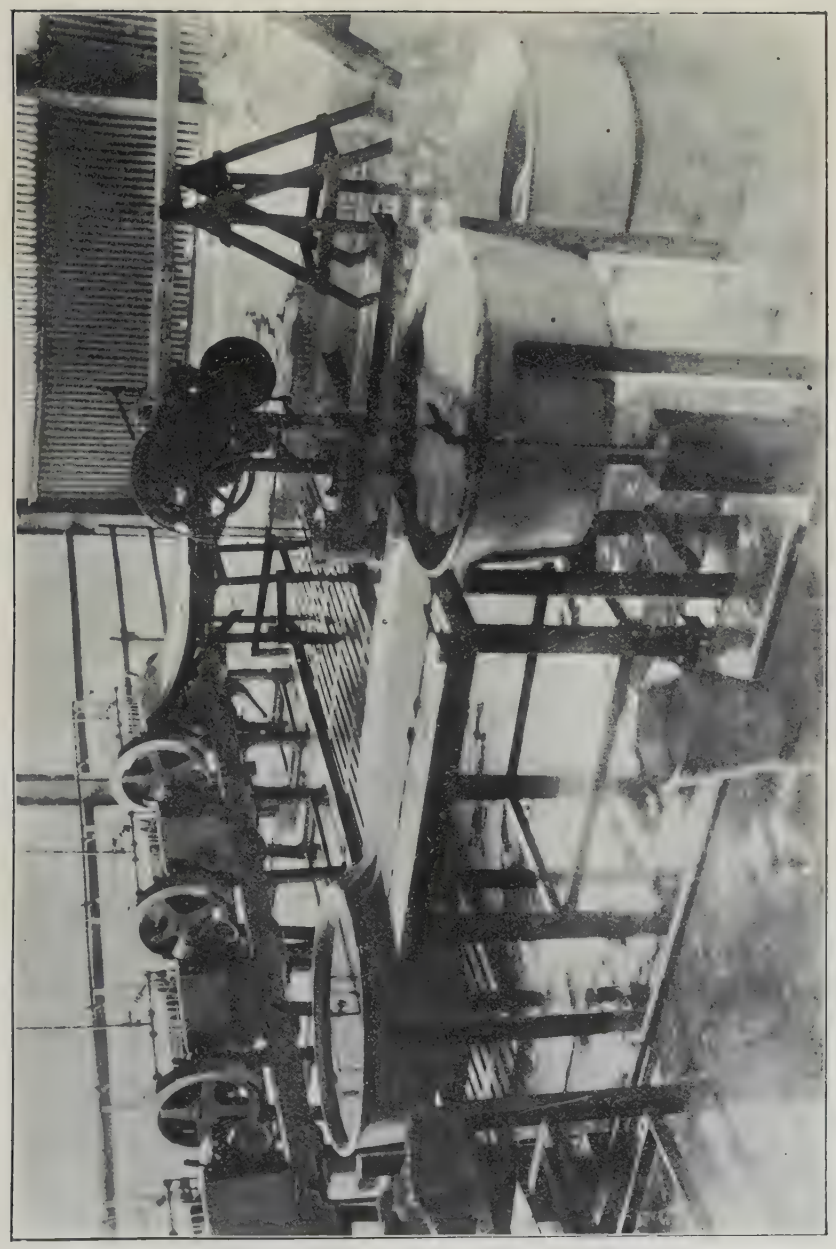
We also wish to thank Mr. Gunnery of this Institute for taking the photographs used to illustrate this article.



Sheeting Battery showing conveying trough in front of Machine.

PLATE I.

PLATE II.



Sheeting Battery showing chute for conveying coagulum to First Machine.

General view of Coagulating Tanks, Chute connecting Tanks to First Machine, and Sheeting Battery.
At the time when this photograph was taken the plant was handling 1,200 lbs. of dry rubber per hour.
Note the entire absence of accumulations of partially treated coagulum and unfinished sheet.

PLATE III.

MANGANESE IN RAW RUBBER.

BY

R. O. Bishop & K. C. Sekar.

It is generally accepted that manganese in small quantities is essential to plant life and the presence of manganese in raw rubber is consistent with its occurrence in products of vegetable origin. There is, however, an accepted limit to the proportion of this element normally present in plantation rubber and it is not unreasonable to suppose that any factor likely to raise this proportion may lead to abnormalities in the characteristics of the product. The method of combination of the manganese, that is the particular salt or compound of manganese present in the product, is also probably of considerable importance.

In the types of plantation raw rubber which are of interest at the present time, it has been suggested that the presence of an abnormal proportion of manganese is associated with an increased tendency to tackiness in the rubber after storage.

Bruni estimated the amount of manganese in sound rubber, slightly tacky and very tacky samples and found that slightly tacky samples contained at least eight times the amount of manganese occurring in sound rubber, while the very tacky samples which Bruni examined contain 100 times more manganese than that normally present in plantation crepe or sheet.

No data are yet available to indicate the extent of the natural variations in the manganese content of latex and the influence which these variations might have on the ageing properties of raw rubber, but it would appear that any chemical or mixture designed for use in the preparation of plantation rubber must be viewed with some suspicion if by its use there arises the likelihood of introducing manganese into the product.

In connection with the proposed use of a certain proprietary fungicide it has been found necessary to examine a number of samples of rubber for their manganese content and it is considered desirable to record the results obtained.

Method of Analysis.—A determination of the manganese content of ordinary normal specimens of plantation rubber was carried out as follows:

A known weight of the sample was completely combusted in a platinum basin in an electrically heated furnace. The residual ash was fused with fusion mixture and the melt was dissolved in water.

This was poured into a mixture of concentrated sulphuric and nitric acids.

The acid solution was filtered from insoluble matter and diluted to a definite volume.

Aliquot portions of the solution were treated with potassium periodate to develop the permanganate colour, allowed to stand overnight and then diluted to a definite volume. The manganese content of the solution was estimated colorimetrically in a Klett Colorimeter by comparison with a standard permanganate solution.

To test the value of the results obtained by the use of the method, a series of determinations were made on samples of rubber to which known amounts of manganese had been added in the form of potassium permanganate.

Standard smoked sheet was masticated on the mixing rolls and when sufficiently plastic it was calendered to a thin sheet and dusted with known weights of potassium permanganate powder. The treated rubber, was folded and again macerated and finally rolled to a ball suitable for sampling. From 200 grms. of the mixture duplicate lots of 5 grms. were examined with the following results.

Manganese Added.		*Manganese Found.*
M.Gms. $KMnO_4$ per 100 grms. Rubber.		M. Gms. $KMnO_4$ per 100 grams. Rubber
a	5	3.8
b.	10	6.6
		6.8
c.	20	15.0
d.	30	29.0
		30.0

As it was considered that the differences observed might be due to the mixing, further investigations were carried out to test the value of the analytical method applied to the estimation of manganese which had been added to rubber ash.

A sufficiently large quantity of standard smoked sheet was combusted and potassium permanganate solution was added to the ash in the proportion of 0.005 grms. to 100 grms. of rubber. By subsequent colorimetric determinations the proportion found was 0.004 grms. to 100 grms. rubber.

It was obvious therefore that the method of analysis gave low results but that the figures obtained were of a sufficiently correct order to serve as a useful guide to the actual manganese content in any abnormal samples.

For the purpose of collecting information on the effect of introducing manganese into rubber at the time of coagulation, trials were carried out with a locally prepared proprietary fungicide known to contain manganese.

The fungicide solution is intended for addition to latex prior to coagulation. It contains a quantity of suspended matter which for the purpose of these trials was filtered off. By the analytical method

described above the filtered solution was found to contain manganese equivalent to 0.20 grms of potassium permanganate per 100 ccs. while the unfiltered solution contained manganese equivalent to 0.94 grms. of potassium permanganate per 100 ccs.

Using the fungicide solution in the proportions recommended by the makers, i. e. 1 oz. to 1 gallon of pure latex or 1 part of liquid to approximately 50 parts of dry rubber, a number of sheets of rubber were prepared in the usual manner. Formic acid solution was used to coagulate the latex to which the fungicide had been added. Controls coagulated from the same latex by formic acid alone were prepared at the same time.

The dry rubber was sampled and combusted and the manganese determined according to the method described above.

The manganese contents of the above sheets and control sheets for three separate series of coagulations together with the manganese content of random specimens of other standard types of rubber, as well as those examined by Bruni, are recorded below in Table I & II.

TABLE I.

	Manganese Content. *Mn. (mgms. per 100 grms. rubber.)*		
Date of Coagulation ...	5.5.30	6.5.30	7.5.30
Manganese Content of Rubber prepared from Latex with Fungicide ...	1.7	1.1	1.0
Manganese content of Rubber prepared from Latex without Fungicide ...	0.2	0.1	0.1

TABLE II.

Manganese Content of representative samples of plantation rubber.

	Mn. (mgms. per 100 grms. rubber.)
Plantation Crepe	... 0.11
2nd Fraction Crepe	... 0.37
Smoked Sheet	... 0.14
Para Rubber	... 0.17
Slab Rubber	... 0.15

(A)

Manganese content of samples recorded by Bruni.*

Samples of Sound Rubber.	*Mn. (mgms. per 100 grms. Rubber.)*
Fine Para	... 0.18
Smoked Sheet	... 0.12—0.25
Crepe (first Latex)	... 0.06—0.25
Slab Crepe	... 0.12

* India Rubber Journal Vol. LXII No. 3 July 16, 1921 p. 15. (Paper read at Fifth International Rubber Exhibition 1921).

(B)

Samples presenting heavy and uniform Tackiness.	*Mn. (mgms. per 100 grms. Rubber.)*
Smoked Sheet	... 20.0
Brown Crepe	... 20.0
Washed Crepe	... 10.0
Slab of Congo Rubber	... 3·75

(C)

Samples presenting light and irregular Tackiness.	*Mn. (mgms. per 100 grms. Rubber.)*
Pale Crepe	... 1.0 —2.5
Dark Crepe	... 2.5 —3·75
Brown Crepe	... 0.62

AGEING.

Potassium Permanganate added to Latex.—In order to obtain information on the relative ageing properties of raw rubber containing varying amounts of manganese which had been added in the form of potassium permanganate, specimens from the above samples, prepared with the proprietary fungicide, were stored in an electric oven maintained at a temperature between 50°C. and 55°C.

No appreciable difference in stickiness was found between the control samples and those prepared from latex containing the proprietary fungicide. An examination was made of a sheet of rubber supplied by the manufacturers of the fungicide and reported to have been prepared according to their specification 11 months previously. The rubber had the appearance of smoked sheet and exhibited no superficial defects. It was entirely free from mould. Samples of the sheet were found to contain 3.7 to 4.3 milligrams of manganese per 100 grms. of dry rubber. From these results it may be inferred that the use of the fungicide in the amount specified has not materially influenced the ageing properties of the raw rubber.

Further "ageing" tests were carried out on specimens of sheet prepared from latex to which larger proportions of manganese had been added in the form of potassium permanganate.

Table III gives particulars of the amounts of manganese added to the latex, the amounts of manganese actually found in the rubber and the observations on the behaviour of the rubber after storing in an oven at 50°—55°C. The potassium permanganate solution was added to latex collected fresh from the field. The latex was diluted to a dry rubber content of 15 per cent. After the addition of the permanganate the latex was coagulated with formic acid in the usual manner, and the coagulum rolled to sheet and dried according to normal procedure. Control coagulations of latex not treated with permanganate were carried out at the same time.

From the results recorded it is evident that a large proportion of the manganese is removed from the rubber during the course of coagulation and subsequent washing of the sheet, but the manganese which remains in the dried coagulum is sufficient to cause development of stickiness under accelerated conditions of ageing.

TABLE III.

Effect of storing rubber containing added manganese. Manganese added to latex as permanganate solution.

Specimen.	Manganese Content mgms. per 100 grms. Rubber.		Period of Storage	Observations.
	Added.	Found.	Hours.	
Control	Nil	0.26	300	No appreciable stickiness.
Latex + Permanganate	23.5	3.96	300	Slightly sticky.
Latex + Permanganate	35.5	4.54	300	Slightly more sticky.
Latex + Permanganate	47.5	5.30	300	Slightly more sticky.

Potassium Permanganate added to Rubber.—Further observations were made on specimens of crepe rubber to which the permanganate had been added in the form of drops of solution. The crepe rubber was hung in the air at the ordinary laboratory temperature, approximately 85°—90°F. (29°—32°C.)

The results are recorded in Table IV.

TABLE IV.

Storage of crepe spotted with potassium permanganate solution.

Specimen	Amount of Permanganate		Period of Storage	Observations
Pale Crepe	Strength of solution. mgms $KMnO_4$ per 100 ccs solution.	Number of Drops added	Days	
1	0·02	10	120	No stickiness
2	0·05	10	3	Very slight stickiness
3	0·05	10	30	Appreciable stickiness
4	0·10	10	3	Very slight stickiness
5	0·10	10	12	Slight stickiness
6	0·10	10	30	Very appreciable stickiness
7	0·20	10	3	Slight stickiness
8	0·20	10	12	Much more sticky
9	0·20	10	30	Very sticky
10	0·50	10	3	Slightly sticky
11	0·50	10	12	Very sticky
12	0·80	10	3	Slightly sticky
13	0·80	10	12	Very sticky
14	Proprietary Fungicide.	4	11	Very slightly sticky
15	,,	4	15	Slightly sticky
16	,,	4	30	Appreciably sticky

Vulcanisation Tests.

The effect of the addition of permanganate to latex either in the form of an aqueous solution or in the form of the proprietary fungicide described above, has been examined in relation to the vulcanisation of the rubber. Representative specimens of the rubber prepared

from latex with and without added manganese were mixed on the warm rolls and vulcanised at a temperature of 148°C, according to the usual routine procedure adopted. Vulcanised rings were tested on the Scott machine. The stress strain curves obtained are given in Figures I & II to indicate the difference between the manganese rubbers and the corresponding controls prepared from the same latex. Curve 3 represents the samples from latex to which no permanganate was added.

The curves show a definite retardation in rate of vulcanisation caused by the addition of the permanganate.

SUMMARY.

(1). The effect of the addition of manganese in the form of potassium permanganate on raw rubber is described and it is shown that the presence of manganese in raw rubber, above that normally present in first grade plantation sheet and crepe and well prepared lower grades, is deleterious by virtue of the fact that tackiness of the raw rubber results.

(2) Any treatment of latex or raw rubber with potassium permanganate must be viewed with suspicion.

(3) Potassium permanganate is only a weak disinfectant especially at low concentrations and its use as a fungicidal agent in latex or raw rubber is not recommended.

(4) The addition of anti-oxidants may eliminate or reduce the deleterious effect caused by manganese compounds.

Investigations on this problem are necessary and will be carried out later.

(5) Further investigations are also essential on the effects of different compounds of manganese.

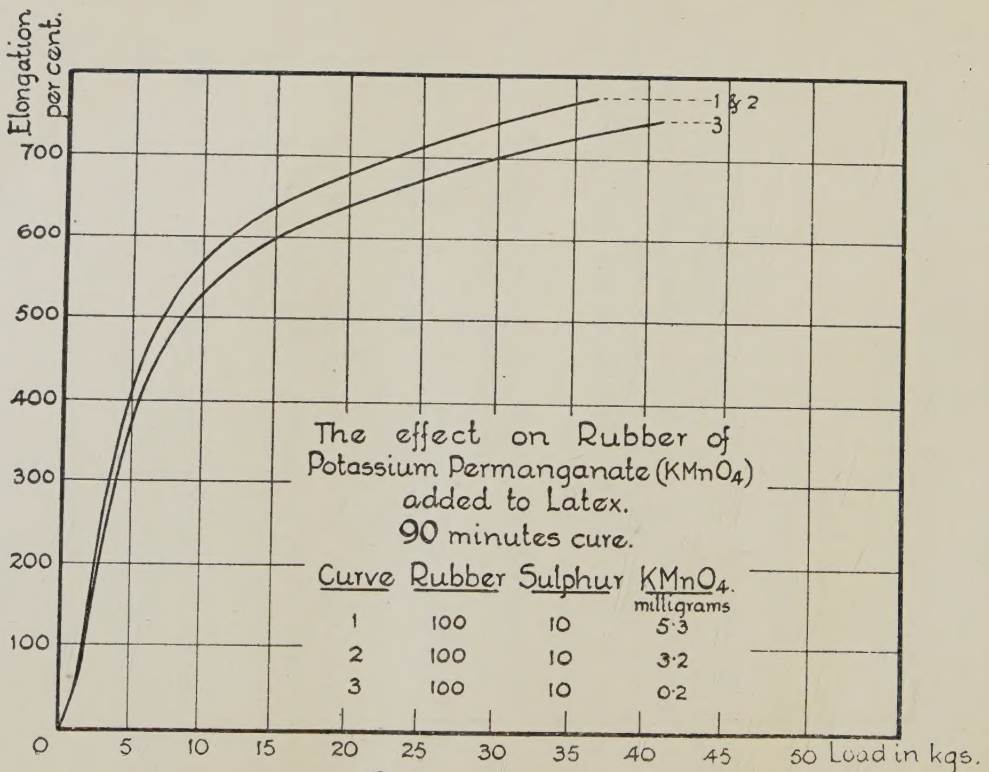
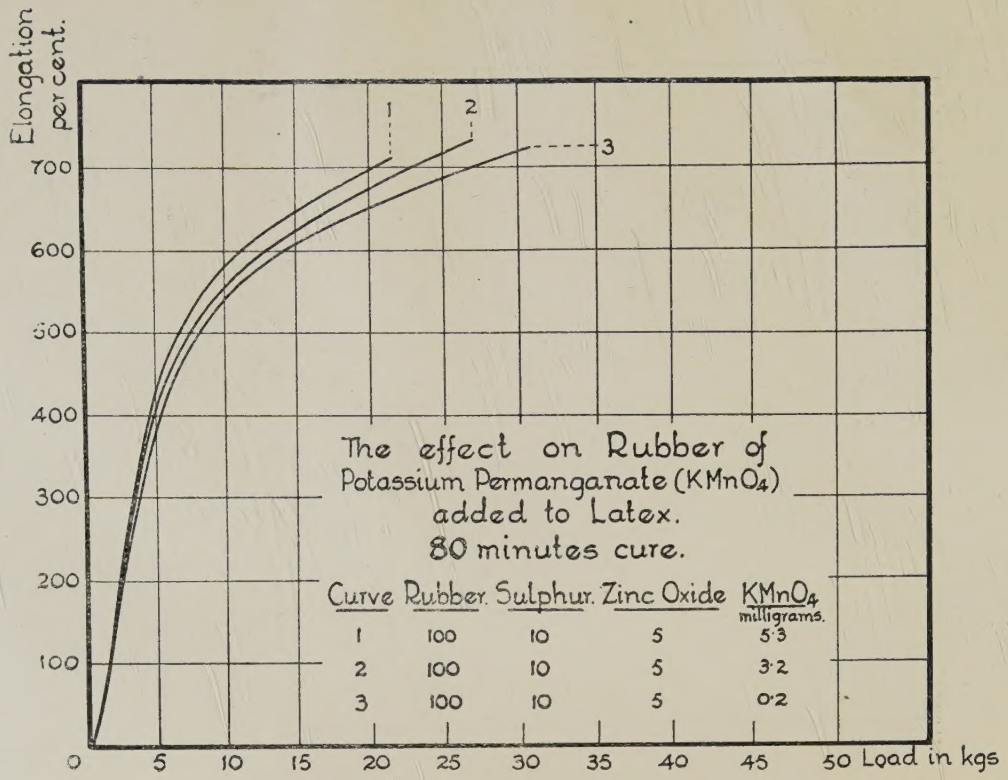

Elongation per cent.
700
600
500
400
300
200
100
0
5
10
15
20
25
30
35
40
45
50 Load in kgs.
1 & 2
3
The effect on Rubber of Potassium Permanganate ($KMnO_4$) added to Latex.
90 minutes cure.
Curve Rubber Sulphur $KMnO_4$. milligrams
1 100 10 5·3
2 100 10 3·2
3 100 10 0·2

Fig: I.


Elongation per cent.
700
600
500
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100
0
5
10
15
20
25
30
35
40
45
50 Load in kgs
1
2
3
The effect on Rubber of Potassium Permanganate ($KMnO_4$) added to Latex.
80 minutes cure.
Curve Rubber. Sulphur. Zinc Oxide $KMnO_4$ milligrams.
1 100 10 5 5·3
2 100 10 5 3·2
3 100 10 5 0·2

Fig: II.